Materials in Design Engineering

SELECTION AND USE OF METALS, NONMETALLICS, FORMS, FINISHES

LOW COST COATINGS FOR METAL PRODUCTS

MANUAL NO. 168

Fluorocarbon Fluids—p 14
Properties of Pearlitic Malleable Iron—p 105
How to Design Honeycomb Sandwich—p 117
Complete Contents—p 1

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MARCH 1960 | VOL. 51, NO. 3

Materials in Design Engineering

FORMERLY MATERIALS & METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

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PUBLISHED BY
REINHOLD PUBLISHING CORP.
430 PARK AVE., NEW YORK 22, N. Y.

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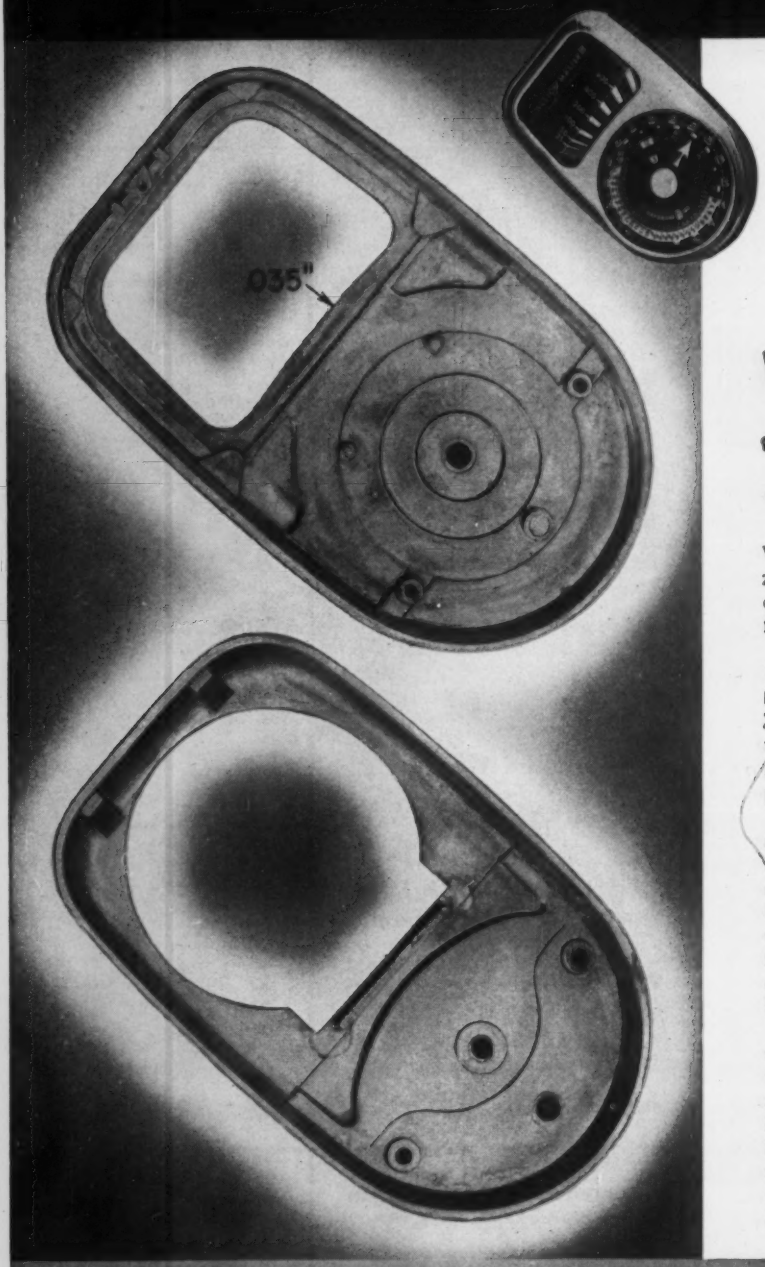
IT'S LIGHTER THAN YOU THINK!



EXCEPTIONALLY ACCURATE... STRONG... ECONOMICAL... WHEN DIE CAST with ZAMAK

WESTON has been using these wafer-thin zinc die castings for the front and back covers of this world-famous exposure meter for 14 years.

Converting from an all-plastic case in 1945, Weston selected zinc die casting alloys for this popular precision instrument because ZAMAK offered the most in all-'round advantages. High strength combined with the lightness of a thin-wall zinc die casting were primary considerations.

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As in many other applications, such extremely thin wall sections – possible only with zinc die castings – minimize weight and are stronger **in proportion to thickness** than heavier sections. Such parts designed for ZAMAK alloy die casting will more than meet competition of either stampings or aluminum castings – provide many more advantages and all at lower cost.

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For more information, turn to Reader Service card, circle No. 371

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Uses of Friction Materials
Take Advantage of Gravity Die Casting
How to Join Honeycomb
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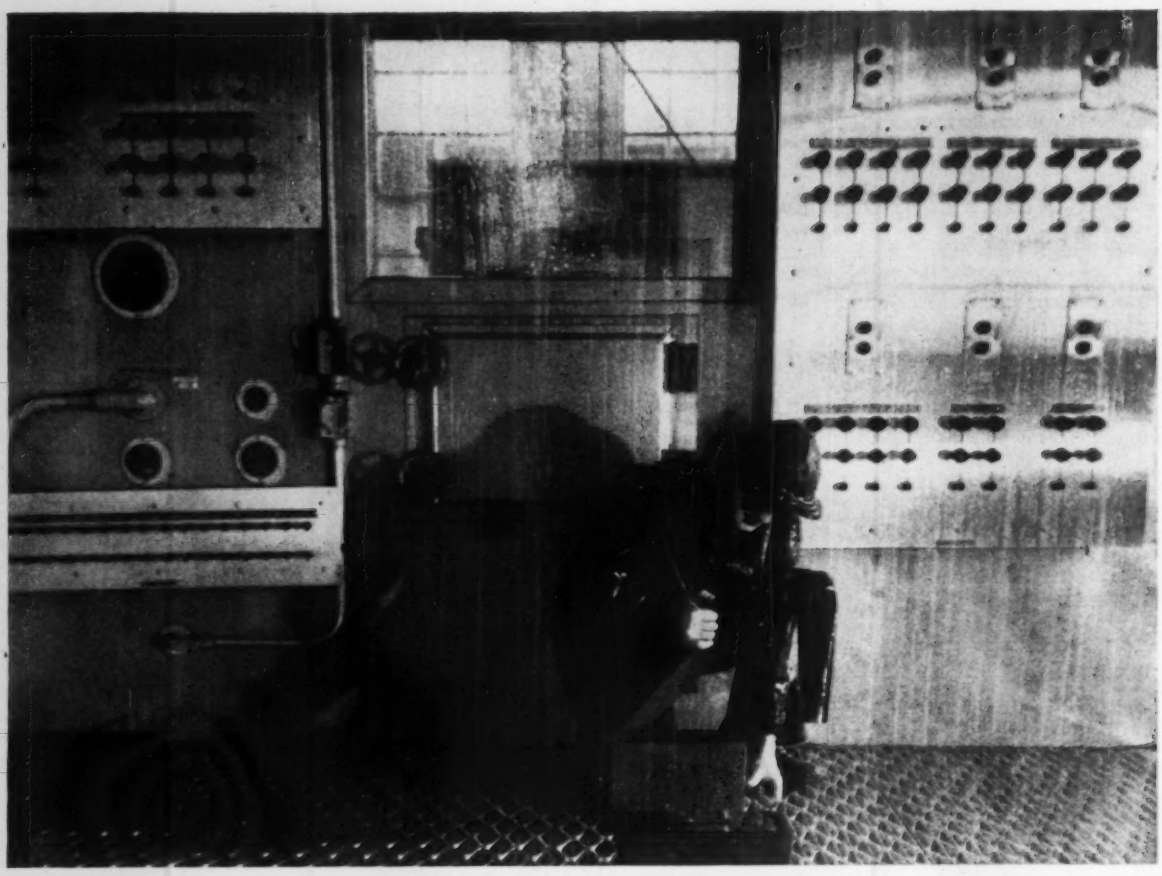


In test chambers of the U. S. Army...

Nickel meets the torture of man-made weather

Sometimes it's as steaming as the Malayan jungle...sometimes as hot as the Sahara...and then an arctic storm blows in. Nowhere in the world does Nature brew up such changeable weather as men do in Philadelphia.

Here in weather chambers of the U.S. Army, military equipment undergoes weather conditions that make Mother Nature seem like a gentle old soul by comparison.

If you think this is tough on the equipment, how about the chambers themselves. The equipment is in and out, but the chamber has to take it for test after test. That's why the designers line them with a Nickel Stainless Steel—Type 18-8. Nickel Stainless Steel *can* take it. It's corrosion resisting in the wettest atmosphere. It withstands sub-zero temperatures. The shocks of see-sawing "weather" conditions harm it not at all.

Still another Nickel alloy—a nickel-chromium type — lines heat test units where temperatures get up over 1200°F. Another nickel-chromium alloy is used for the glowing heating elements.

Make your own forecast of what a metal must face—Nickel and its alloys can help you meet the challenge. Is it ability to meet stress, fatigue, heat or cold, corrosive atmospheres or a combination of these? We may be able to help you find the answer in Nickel. Just write.

Weather chambers like this one designed by Tenney Engineering, Inc., Union, N. J., are lined with Nickel Stainless Steel. Notable installations include those at the U. S. Army's Frankford Arsenal, and Sperry Gyroscope Company, Long Island, N. Y.

The International Nickel Company, Inc. INCO **67 Wall Street · New York 5, N. Y.**

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

What's new IN MATERIALS

...AT A GLANCE

Columbium metal can be protected against oxidation at 2200 F with a new metallic coating. Using zinc as a starting material, the coating forms a protective layer of zinc columbium oxide. The coating is said to be ductile at high temperatures, and to heal itself if bare spots develop.

Source: U. S. Naval Research Laboratory, Washington, D. C.

Radically new epoxy resins, designed for laminating or casting, promise lower cost, more heat resistance (heat distortion temperatures of about 375 F), and stronger parts than obtainable with conventional epoxies. The resins, epoxidized polyolefins, will probably cost about the same as other epoxies; however, because they are highly reactive with low cost anhydride hardeners, a finished laminate will probably cost less than a conventional epoxy laminate. (More details next month.)

Source: Food Machinery & Chemical Corp., 161 E. 42nd St., New York 17.

A new high temperature epoxy formulation has been developed. Based on peracetic acid-derived epoxies, the resin meets requirements of MIL-R-9300-A, Type II parts. The cured resin is said to retain a high percentage of its original mechanical properties up to 550 F. Uncured, the resin has excellent wetting characteristics, long pot life, and good shelf life in B-stage prepregs. (More details next month.)

Source: Brunswick-Balke-Collender Co., Marion, Va.

Perforated metal with trapezoidal, tapered openings is said to last up to three times longer than conventional perforated metal in screening, filtering and dewatering applications. Key to the material's long life are humps on the working side of the metal that act in a "shovel-like" way to guide material to the openings. The perforated metal is supplied in the form of sheets, cones and cylinders.

Source: Cross Perforated Metals Co., Div. of National-Standard Co., Carbondale, Pa.

Scented polyethylene films and molded products are now available for packaging and other applications. Parts can be scented with pine, cedar, spruce and lavender, or "flavored" with lemon, lime, orange and strawberry.

Source: U. S. Industrial Chemical Co., Div. of National Distillers & Chemical Corp., 99 Park Ave., New York 16.

Finely divided polyethylene powder is available for coating metals, textiles, paper, wire and glass; and for molding large shapes by fusion techniques, such as the one described on p 11. The powdered resin is supplied in particle sizes as small as <200 mesh. It can be applied as a powder by the fluidized bed technique, as a dispersion in water or alcohol, or as a paste.

Source: U. S. Industrial Chemical Co., Div. of National Distillers & Chemical Corp., 99 Park Ave., New York 16.

One-coat porcelain enameled parts for appliances can be obtained with a new enameling iron now available in limited quantities. Composition has not been revealed. Big advantage of the new material is that it assures freedom from "fish-scaling" (enamel surface defects) and "boiling" (liberation of gases during firing).

Another advantage: one-coat enameled parts have better resistance to mechanical damage than parts enameled by conventional two-coat systems.

Source: Armco Steel Corp., Middletown, Ohio.

A ferroelectric ceramic can be used up to 660 F. Available in the form of spheres, bars, cylinders and blocks, the ceramic is a modified "lead zirconium titanium" formulation that is said to maintain its piezoelectric properties at high temperatures. Conventional ferroelectric ceramics withstand temperatures up to 212 F. The ceramic parts are expected to be used in sonar systems, hydrophones, ultrasonic cleaners and similar devices.

Source: Universal Dynamics Corp., Div. of Acoustica Asso., Inc., 130 Los Aguajes Ave., Santa Barbara, Calif.

An all-acrylic paper electrical insulation is designed for Class B (265 F) insulation use. The paper consists of acrylic fiber (Orlon) and acrylic resin, produced by a beater addition technique and conventional papermaking processes. The material is expected to find use in hermetically sealed electrical systems where resistance to Freon-oil mixtures is critical.

Source: Rogers Corp., Rogers, Conn.

Two new finishing treatments for magnesium have been developed. One is a ferric nitrate bright pickle that provides a semi-bright to bright silvery finish on wrought and cast magnesium parts. The other is a chromium pickle that provides a uniform finish on magnesium casting alloys of high aluminum content.

Source: Dow Metal Products Co., Div. of Dow Chemical Co., Midland, Mich.

Highly oriented fibrous resins for incorporation into paper and nonwoven fibers are available in developmental quantities. Two resins, a vinyl copolymer and a polystyrene, are currently available. Fiber lengths vary from very short to a maximum of 3/16 in., and diameters range from 2 to 200 μ.

Source: Union Carbide Plastics Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17.

Titanium alloy scrap can be reprocessed by induction melting to produce castings with mechanical properties almost as good as those of forged titanium. The process is said to be economical.

Source: Rpt. No. PB 151572, Office of Technical Services, Dept. of Commerce, Washington 25, D. C.

An improved, easy-to-process fluoroelastomer is commercially available. The material, called Fluorel and introduced last spring (see M/DE, May '59, p 152), is said to have a Mooney scorch rating almost three times that of the original product, which is in the ideal range for rubber processing. It sells for $10 per lb.

Source: Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

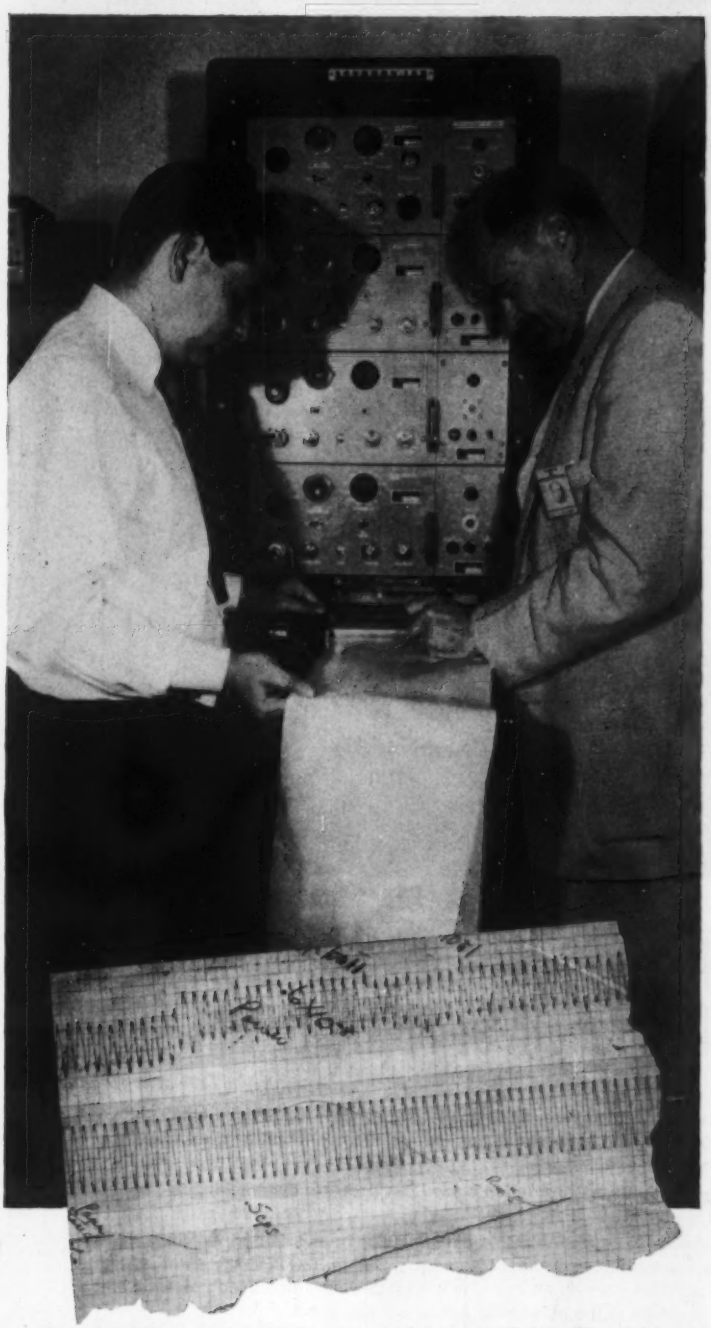
Aluminum parts can be 'hard anodized' in 1 min by a new electrochemical technique that operates at room temperature and at a current density 20 to 40 times higher than that of other methods. Conventional hard coatings are applied to aluminum in 10 to 50 min at 25 to 50 F. The new method produces a light-colored anodic coating, 0.001 in. thick, that is claimed to have the same hardness, abrasion and corrosion resistance, frictional properties, electrical resistance and density as conventional hard anodic coatings. The process is not yet commercially available. (More details in a forthcoming issue.)

Source: Toro Mfg. Corp., Minneapolis 6, Minn.

Turn to page 9 for more "What's New in Materials"

Another new development using

B.F.Goodrich Chemical *raw materials*



"Heatrace" heat-sensitive chart paper manufactured by Nashua Corporation, Nashua, N.H., using Hycar nitrile latex is being used for medical and industrial applications—including all Minitrack installations around the world. B.F.Goodrich Chemical Company supplies the Hycar nitrile latex.*

**Trade Mark*

Hycar helps new chart paper make a faster, better record

This new heat-sensitive chart paper improves the accuracy of line and legibility of tracings because it is more sensitive to a heated stylus. It is made with a base coating of Hycar nitrile latex.

Originally designed to improve the resolution of electrocardiograms, the new paper is also proving ideal for high-speed space instrumentation. The base coating of Hycar provides a water-proof structure that prevents graying of the surface coating under high humidity conditions. This smooth, flexible coating also adds to the paper's durability, making it particularly useful where extensive handling is required.

In latex forms like this, and in many other forms, Hycar nitrile rubber is adding advantages to products—or opening whole new markets. For more information, write Dept. FN-2, B.F.Goodrich Chemical Company, 3135 Euclid Ave., Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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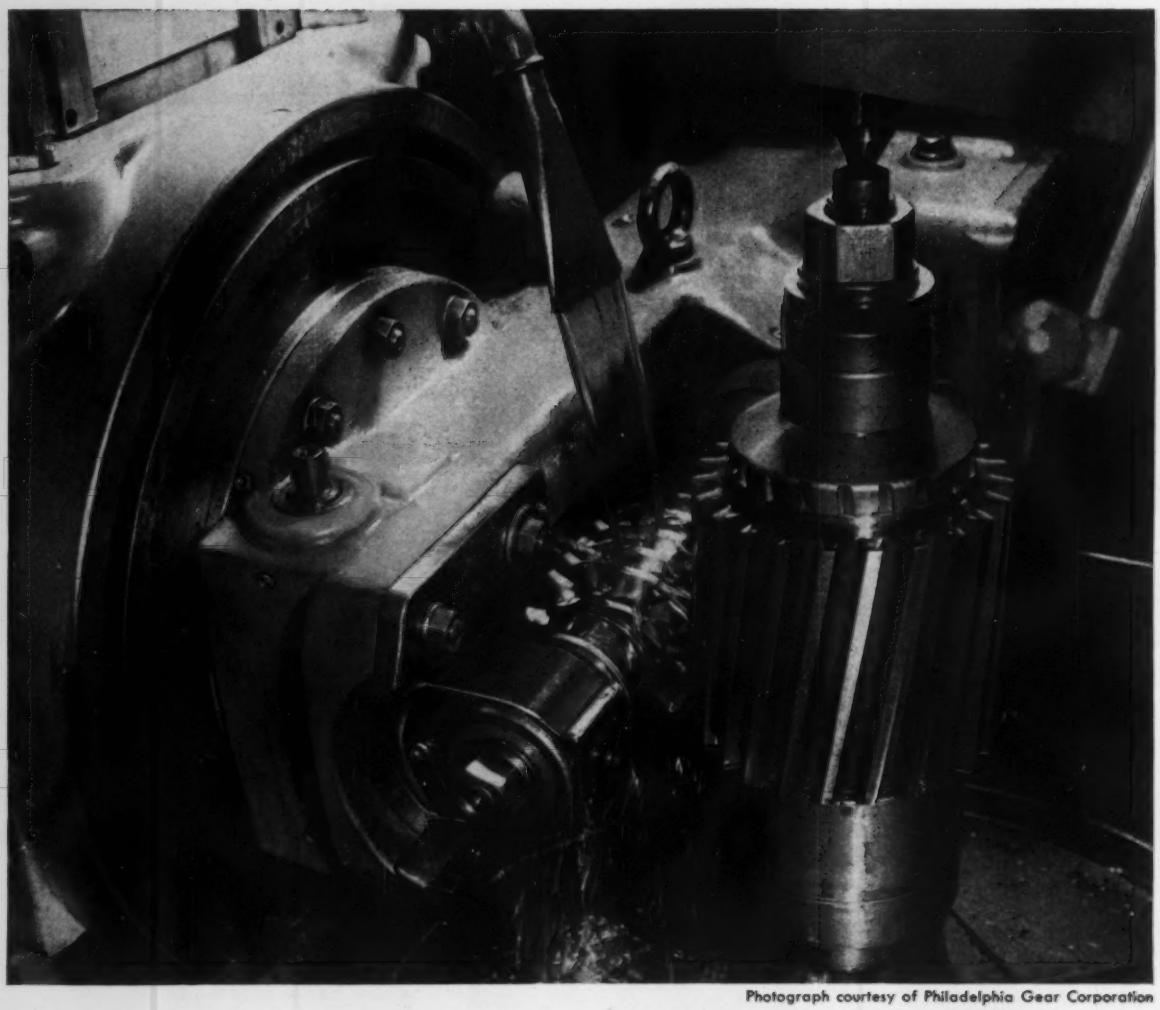

Photograph courtesy of Philadelphia Gear Corporation

Aristoloy LEADED* provides freer machining with no sacrifice of tensile strength at PHILADELPHIA GEAR

ARISTOLOY STEELS

The very qualities that make good gear steels—high-tensile strength, extreme wear and load resistance—make them difficult and expensive to machine.

Philadelphia Gear Corporation solved this problem by switching to Copperweld leaded steel.

This helical gear, for example, is being cut from a bar of Aristoloy 4140 leaded which has been heat treated to a 300 to 320 Brinell Hardness. The lead addition permits an increase in spindle RPM, increased hob feed and improvement in the number of pieces per tool grind.

But none of the desirable strength qualities required of a gear steel are reduced by the minute lead particles. They act as built-in lubricant and in no way affect the physical properties.

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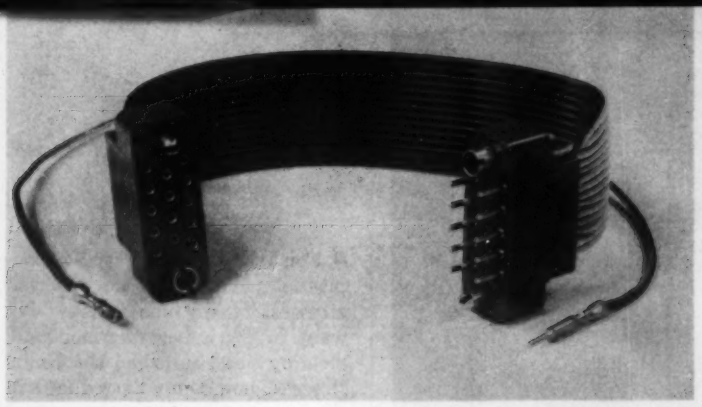


***Multiple-conductor** ribbon cable is a typical use.*

Corona Resistance Boosted 70-Fold in New TFE Wire Insulation

Its resistance is now comparable to that of silicone rubber

■ The resistance of TFE fluorocarbon (Du Pont's Teflon) to corona stress when used in TFE-coated wire has been increased upwards of 70 times. This development is said to make the corona resistance of TFE comparable to that of silicone rubber and to boost the maximum service temperature of corona-resistant wire to about 600 F.

Developed by W. L. Gore & Associates, Inc., 487 Paper Mill Rd., Newark, Del., the new TFE-coated wire virtually eliminates failure under corona stress. Fig 1 and 2 compare average corona life of the new wire, designated Mono-Tet CR, with that of average, high quality, TFE-coated hook-up wire.

TFE has always been quite susceptible to corona stress. Although there have been other materials with far better corona resistance, none have had TFE's electrical properties and heat resistance. Now excellent corona resistance has been added to TFE's excellent electrical characteristics.

Compounding and processing make the difference

Performance of the new TFE-coated wire is based on two developments: 1) a special formulation compounded to minimize corona initiation and prevent cavity growth, and 2) new manufacturing techniques that result in an essentially void-free coating. The covered wire is 100% water-bath-tested at voltages higher than those required by normal specifications to assure close quality control.

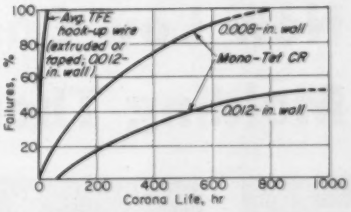
The insulated wire is available as Mono-Tet CR single-conductor wire in sizes from AWG 28 to 0, in ten basic colors and with stripes. It is also available in shielded and coaxial conductors, and as Multi-Tet CR in multiple-conductor ribbon cable.

The corona problem

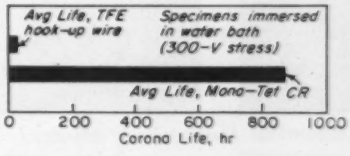
Many engineers experience insulation failures due to corona stress without realizing the true cause, or just how it occurs. Corona begins with ionization resulting from increasing voltage stress.

Like all wire coatings, TFE-coated wire normally contains microvoids at the coating-wire interface. Ions formed by high voltage stresses are bounced around in these minute cavities by an alternating current. When they bombard the internal surfaces of the void they cause heat. The combined effects of impact and heat begin to enlarge the cavities. As the cavities grow, heat and extent of ionization increase until the ions finally break through the insulation.

Aircraft and missile wiring is especially prone to corona failure because the voltage level at which corona starts decreases with decreasing atmospheric pressure. For example, at sea level corona stress may begin at about 2000 v in a typical 10-mil insulation; at high altitude, initiation level may be reached at less than 1000 v.



1 *Percentage of failures due to corona stress is plotted against hours of life for two thicknesses of the new coated wire. Two average, high quality, TFE hook-up wires are included for comparison. Corona started in all specimens between 1800 and 2600 v.*



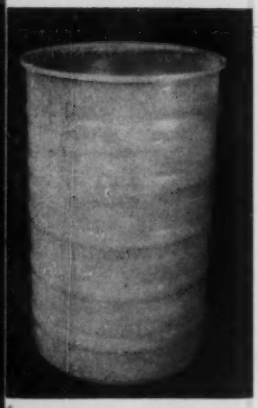
2 *Comparison of average life under corona stress shows substantial improvement in new coating, as compared with conventional TFE hook-up wire.*

For more information, circle No. 600

Pleasure boats—*This 10-ft boat has a low-cost, one-piece polyethylene hull. It is molded commercially in Europe by the Engel process.*

These large polyethylene parts were made by a

New Low-Cost Method for Molding Thermoplastics



Chemical tanks—*Both cylindrical and rectangular tanks can be produced economically.*

■ For inexpensive, large thermoplastic parts with no internal stresses, many engineers will want to try a new thermoplastic molding process, called the Engel Process, now being introduced in this country. Although initial production in this country will be in polyethylene (as has commercial production in Europe), minor variations should make the process suitable for forming a variety of thermoplastics, such as polypropylene and nylon.

Spencer Chemical Co., Dwight Bldg., Kansas City, Mo., holds the exclusive U. S. license for the process from Vaessen-Schoemaker Co. of the Netherlands. Plans to sub-license will probably be announced by Spencer soon.

How process works

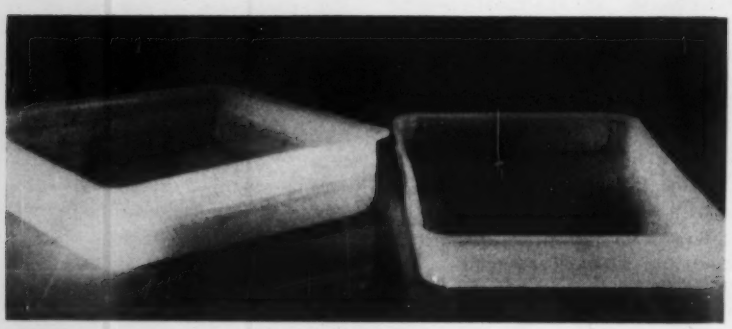
Briefly, the process is as follows:

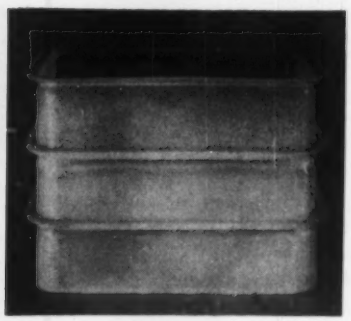
1. Fill a sheet metal mold with powdered polyethylene.

2. Place the filled mold in an oven, which sinters and fuses the polyethylene adjacent to the mold surface.

3. After sufficient time has elapsed to build up the desired wall thickness, remove mold from the oven and pour out the remainder of unfused powder.

Key to the low cost of the process is the construction of the mold, which consists of light-gage sheet metal — commonly stainless steel—which can be shaped by conventional sheet





Delivery boxes—*These lightweight trays are produced at low cost.*

metal fabrication techniques. Such molds also permit large shapes to be formed, size being limited only by oven size.

Thickness of molded sections depends on time and temperature in the oven. Sections ranging from 0.2 to 0.25 in. are common.

Since virtually no pressures are used, moldings are stress-free. Although specific data on properties of parts molded by the new process are not available, properties are believed to be comparable with those of polyethylene sheet.

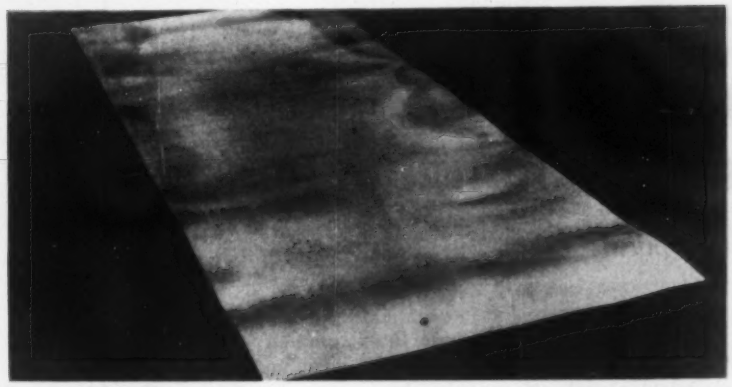
Applications

Products that can be made by the process include large (13-15 gal) reusable carboys, drum and tank liners, tote and delivery boxes, laundry baskets and carts, pleasure boat hulls (in the 10-ft range), and furniture.

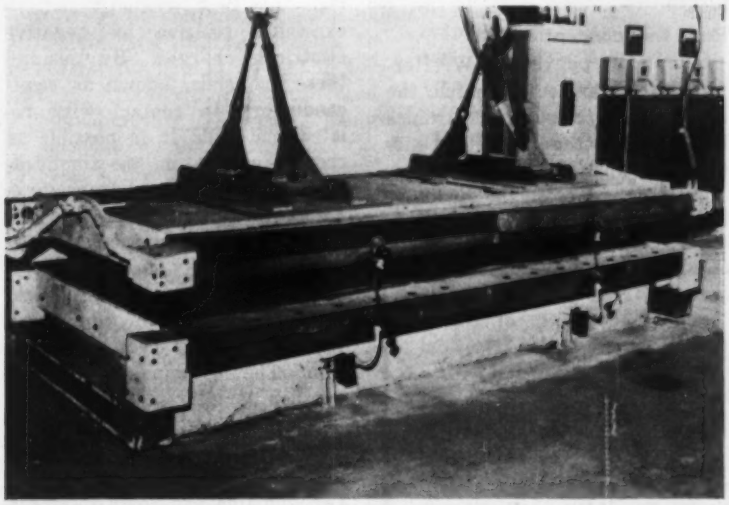
For more information, circle No. 601

New Heat Treatment for Titanium Produces Flatter Sheets

Also: less contamination, more uniform properties



RS-140 sheet, *shown after water quenching from 1520 F, measures 0.040 x 36 x 96 in. Flatness is approximately 2.5%. Best flatness obtained with previous heat treatments: 8 to 10%.*



Sheets can be aged *at the mill with electric platen equipment. Platen heating allows uniform aging and creep flattening.*

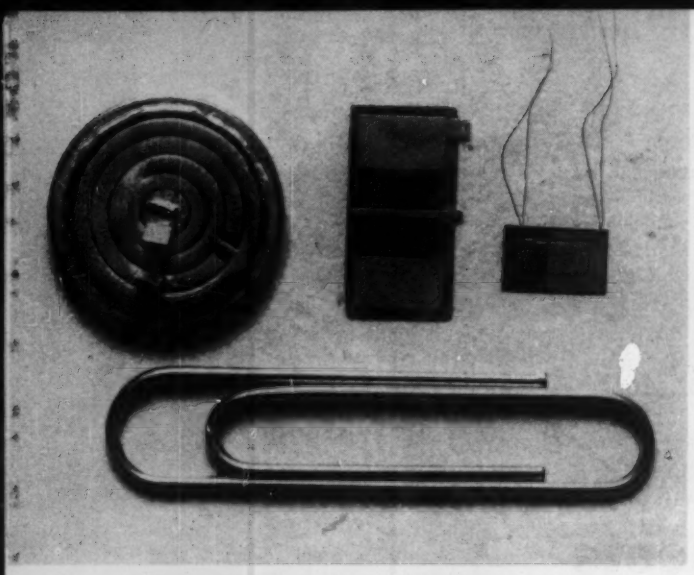
■ Republic Steel Corp., 1441 Republic Building, Cleveland 1, has developed a new heat treating process for producing titanium alloy sheet free of surface contamination, with better flatness and more uniform properties than previously available. The process was developed primarily for RS-140 but has also been used with RS-120A and RS-115 titanium alloys.

A five-zone, electrically heated, continuous roller hearth furnace is used to deliver uniformly heated sheets directly into a continuous roller quenching unit. The sheets are precoated (coating agent not stated) to prevent atmospheric contamination and heated for short periods of time between 1400 and 1700 F, depending on the alloy. The sheets are then water quenched in the continuous roller unit.

Sheets are in the solution treated condition following this processing and may be formed either hot or cold before aging to produce the high strength levels required of the titanium alloys. Republic also ages the sheets in the mill for those applications in which only moderate forming is required, but where high strength is a necessity.

Heat treated RS-140 can be used in skins, stiffness, internal structures, engine nacelles, bulkheads and heat shields in aircraft and missiles. The alloy also offers substantial weight savings over other materials when used as cover sheets on honeycomb sandwich panels.

For more information, circle No. 602



Three tiny function blocks *usable as electronic subsystems include audio amplifier (left), free running multivibrator (center), and two-stage video amplifier (right).*

Audio amplifier *used in phonograph system consists of two small units. Conventional amplifier with its tubes, capacitors, resistors and other components would have ten times as many connections and less reliability.*

Tailor-Made Materials Replace Electronic Components

in new concept of molecular electronics

■ Revolutionary changes in the design of electronic equipment will result from the concept of "molecular electronics" in which tailor-made materials eliminate the need for resistors, capacitors, diodes, transistors and other electronic components.

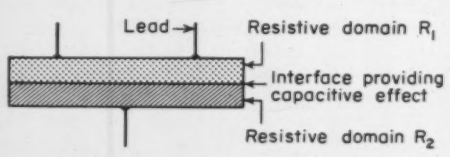
Scientists of Westinghouse Electric Corp.'s Research Laboratories, Box 2278, Pittsburgh 30, can now create, modify and process materials so that they will accomplish electronic functions through solid state phenomena. Although the concept appears to be most useful for controlling electrical signals, it can also be used for controlling the input and output of electromagnetic radiation, heat, and mechanical displacement.

How the concept works

As stated by Dr. S. W. Herwald, vice president–research, the concept of molecular electronics does not use the traditional circuit-component approach to electronics but relies on the structure of matter to synthesize monolithic function blocks whose arrangement and composition permit the control of transformation of energy.

As a result of 30 years work on solid state phenomena, materials have been created that have excessive positive or negative electrical charges. By placing these materials, known as semiconductors, in contact with related materials it is possible to create rectification or amplification, as in diodes and transistors. Effects of this general type are used in molecular electronics by creating—usually in single crystals—a number of distinct operative domains each of which performs a specific electronic function. The domains border one another at interfaces which also perform an electronic function.

The accompanying sketch shows a simple example composed of two domains and their interface. One domain is composed of a resistive material selected and



Simplified diagram *of a molecular electronic function block incorporating an RC circuit suitable for time-delay applications.*

***Wafer-sized** d.c. power amplifier requires only the energy from a flashlight beam to control 40 w of power from two 12-v auto headlights.*

shaped to present a resistance R_1 to the flow of current. The other domain is also resistive, but is so planned that it has a resistance R_2. The reaction between domains causes a capacitive effect. Thus, in one tiny element there is a subsystem equivalent to a time-delay circuit.

How materials and systems are made

Design of an electronic system begins with an analysis of system requirements and the function to be performed by the function block. After logic effects are determined, a topologist—a mathematician who works with shapes—determines the arrangement of domains and interfaces that is to control the flow of energy in the block. The block is then produced by materials engineers using germanium and silicon as the basic semiconductor materials.

The blocks are not assembled from various tiny components. Rather, they are fabricated out of a basic semiconductor wafer. The necessary domains and interfaces are made by techniques used in producing conventional semiconductor devices, including diffusion, plating, electron beam machining, etching, cutting, radiation, alloying and photographic processes. Additional processing steps are required to encapsulate the block and protect it against shock, vibration, heat, radiation.

One of the major breakthroughs in the science of molecular electronics is the development of a method for the rapid production of semiconductor crystals in a form that requires no removal of material to make them into suitable wafers. This method is the dendrite process announced several months ago (see "Germanium Crystals Grown Ready for Immediate Use," M/DE, Oct '59, p 133) in which germanium crystals in the forms of ribbons about ⅛ in. wide and a few thousandths of an inch thick are produced by drawing them from a molten mass. No x-ray or crystallographic examination is necessary, and the surfaces of the ribbon are always correctly oriented, optically flat, and immediately usable as working surfaces.

After continued work with the dendritic method, scientists have recently learned how to grow multizoned crystals as dendrites, directly from the furnace melt. This is a very significant discovery in the new technology of molecular electronics. It makes available basic building blocks having at least three zone layers and two interfaces. Thus, multizone elements can be created with substantially fewer operations.

Actual and potential uses

As a result of a joint program between Westinghouse and Wright Air Development Center, USAF, eight classes of function blocks have been developed to demonstrate the feasibility of molecular electronics at frequencies ranging from infrared to direct current. These function blocks are:

1. Five-watt directly cascaded audio amplifier.
2. Two-stage video amplifier.
3. Frequency selective amplifier with notch filter in a feedback loop around the amplifier structure.
4. Bistable, monostable and astable multivibrators.
5. Variable potentiometer based on logarithmic addition of two inputs.
6. A variety of multiposition switches.
7. Analog-to-digital converter.
8. Two-stage cooler, employing the Peltier effect, for cooling infrared detectors to proper operating temperatures.

Some of these applications are shown in the accompanying photos. Many other applications are envisaged, including ways for molecular electronics to contribute to bio-electronics—the ability to simulate the superior biological capabilities found in animal life. Scientists also foresee development within a few years of a complete communications receiver the size of a pea.

For more information, circle No. 603

For critical lubrication, flotation or electrical insulation . . .

Fluorocarbon Fluids—

Premium Materials for Tough Jobs

by Malcolm W. Riley, *Associate Editor, Materials in Design Engineering*

***Floated gyroscope** uses fluorocarbon flotation fluid.* Sperry Gyroscope Co.

■ At $10-12 per lb—and with as many as 16 lb to a gallon—fluorocarbon oils, waxes and greases are expensive. They are used only where their unparalleled properties are needed for special critical applications. In short, these properties are 1) extreme chemical inertness, 2) thermal stability (useful up to 500-600 F), 3) low temperature fluidity (pour points as low as –90 F), 4) noninflammability, 5) lubricity, and 6) high density.

There are three major areas of use for these specialized fluids:

1. *Lubricants and hydraulic fluids* for critical chemical and thermal environments. Uses include lubricants for oxygen compressors, liquid oxygen handling equipment, valves and fittings handling rocket propellents, and other equipment handling extremely corrosive media.

2. *Flotation and damping fluids,* where their high density (over twice the specific gravity of water) and low temperature viscosity permit improved operation and handling economies in floated gyro and accelerometer components of inertial guidance systems.

3. *Liquid dielectrics and coolants,* where their excellent dielectric characteristics, thermal stability, low viscosity, and good autoconvection characteristics make them useful as liquid transformer insulation, as well as low temperature coolants for high-power transmitting tubes.

Other applications for the fluids include paper impregnants for electrical insulation, spray-on wax coatings for alkali cleaning tanks, and permanent lubricants for instruments and clocks.

Two major types —and their cost

The two major types of fluorocarbon oils, waxes and greases are 1) CFE (chlorotrifluoroethylene), and 2) BFE (bromotrifluoroethylene). The materials are quite similar in chemical resistance and physical properties, except that BFE has a substantially higher density—about 0.086 lb per cu in. (2.4 gm per cu cm), compared with densities ranging from 0.068 to 0.072 lb per cu in. (1.88-2.0 gm per cu cm) for CFE oils and greases.

CFE is the more widely used because of its lower price, i.e., $10-12 per lb. BFE is custom synthesized to meet specific needs; it can range in price from around $150 to $200 per lb, or substantially higher.

CFE fluids, waxes and greases are produced by Halocarbon Products Corp. (Halocarbons), Hooker Chemical Corp. (Fluorolubes), and Minnesota Mining & Mfg. Co. (Kel-F—not to be confused with Kel-F plastics, which though chemically identical are of higher molecular weight, and consequently are thermoplastic solids).

BFE fluids are produced by Halocarbon Products Corp. and Sperry Gyroscope Co. (the latter for internal use only).

Physical and environmental properties

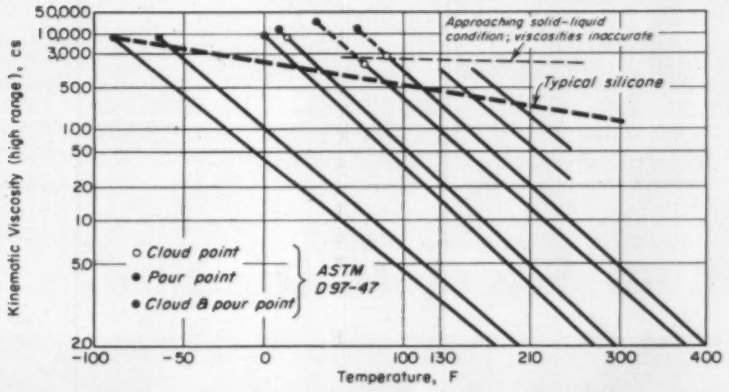
Effects of chemicals and heat—Completely halogenated materials, the fluorocarbons are inert to a variety of corrosive media, including strong acids, alkalis and oxidants; hydrofluoric and fuming nitric acids; hydrogen peroxide; various halofluoride gases; hydrogen fluoride; and various other media.

The materials show no spontaneous ignition in oxygen at 2000 psi at temperatures up to 825 F; no explosion in pure oxygen under an impact of 114 ft-lb; no oxygen pressure drop in the oxygen bomb test (Federal Specification VV-L-791e, Method 3453.1); and no change in color when oxygen is bubbled through the oil for 24 hr at 160 and 300 F.

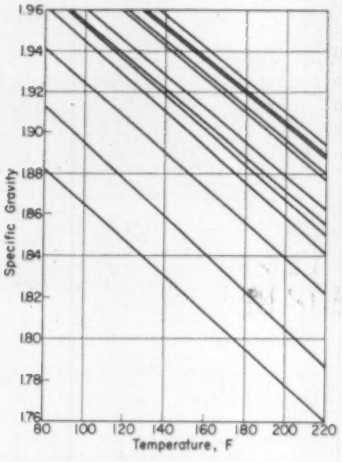
On the other hand, the fluorocarbons should not be used 1) in molten sodium, which reacts to break down the polymer, 2) in aluminum threaded connections where rubbing metallic contact may initiate reaction, or 3) in liquid fluorine or liquid chlorine trifluoride, both of which may react explosively under certain conditions.

The chemical inertness of the materials extends up to their decomposition temperatures (about 550-650 F). Maximum recommended temperature for continuous operation is about 500 F, for intermittent operation approximately 550 F.

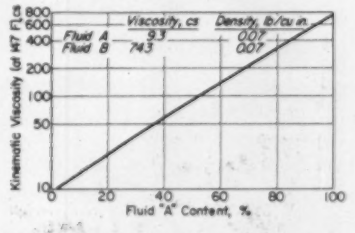
The materials are noncombustible and noninflammable. Products



1—*Typical viscosity-temperature slopes for CFE oils and waxes, showing relatively steep slopes, but extremely low pour points. Note the substantially flatter slope of the typical silicone dielectric liquid shown for comparison.*
(Adapted from data from Halocarbon Products Corp. and Hooker Chemical Corp.)



2—*Typical density-temperature relationship for various CFE fluids.*
(Hooker Chemical Corp.)



3—*Typical viscosity range obtainable by blending two CFE-BFE blends, "A" and "B."*
(Halocarbon Products Corp.)

of thermal degradation will not support combustion and may even tend to extinguish a flame.

Physical properties—CFE products are available as 1) light to heavy oils, of widely varied viscosities and pour points, 2) lower melting waxes, which are not brittle at room temperature, and 3) greases, which consist of blends of various oils and waxes. Some greases contain additional thickening agents; others do not.

Fig 1 indicates the range of viscosities obtainable in CFE oils and waxes. It also shows the admittedly poor viscosity-temperature relationship of the materials. (Slope for a typical silicone dielectric liquid with a good viscosity-temperature relationship is shown for comparison.)

Fluorocarbon fluids are high in density compared with other lubricants and with most organic liquids. Fig 2 shows typical density-temperature curves for CFE oils. Densities can be altered substantially by blending.

CFE materials are available with a wide range of pour points. Some proprietary types of the lightest oils have pour points reported to be as low as –90 F. The heaviest oils have pour points of about 65 F. Waxes have melting points ranging from about 140 to 300 F.

Specific service properties

Lubrication—Reliable, standardized comparative data on lubricity are sparse. In general, CFE oils are said to exhibit the lubricity of a pure extreme pressure additive. According to 3M, "mean Hertz load of Kel-F No. 10 Oil, as determined by 10-sec runs in the Shell 4-ball E.P. Tester, is 120 kg—a value that compares favorably with typical values of 70-80 kg for commercial gear lubricants."

Hooker provides the following test values as indicative of the lubricity of its Fluorolube HO:

Timken Test, lb	28
SAE Test	>580
Shell 4-Ball Wear Test, mm wear scar per kg load	
1 Kg Load	0.10
10 Kg Load	0.38
40 Kg Load	0.65

Halocarbon quotes values obtained from Ryder gear tests recently conducted by the Air Force which indicate load-carrying ability of one of its fluids as being over 40,000 lb.

Flotation and damping—High density BFE fluids, or blends of BFE and CFE, have provided optimum performance as flotation fluids for gyro or accelerometers used in inertial guidance systems. Fluids originally used for this purpose become solids at room temperature and freeze at subzero temperatures. Consequently, during transit or storage the whole system had to be artificially heated to prevent fissures or cracks which might occur in the solid material.

Fluorocarbon fluids, which provide the required high density, have the low viscosity at room temperature required to eliminate this problem. BFE oils are clear liquids at room temperature, and noncracking solids at –65 F. Viscosities of BFE oils range from 1.84 cs for light oils to 5619 cs for heavy oils (at temperatures of about 145-190 F). Viscosity and density can be altered widely —and independently of each other —by proper blending. Fig 3 shows the viscosity range obtainable by blending only two CFE-BFE blends, indicating the wide range obtainable by altering the blending components.

Dielectrics— Fluorocarbon oils and waxes have good electrical insulating properties which, to-

gether with thermal and chemical stability, make them useful for many electrical uses.

Dielectric strength usually ranges around 350-500 v per mil; volume resistivity is more than 10^{14} ohm-cm.

Additional information on fluorocarbons' uses as liquid dielectrics can be found in "Synthetic Fluid Dielectrics," M/DE, Nov '59, p 99.

For more information on CFE fluids, circle No. 604; on BFE fluids, No. 605

Clad Molybdenum Sheet Is Ductile

Can be used in semiconductor products and electronic tubes

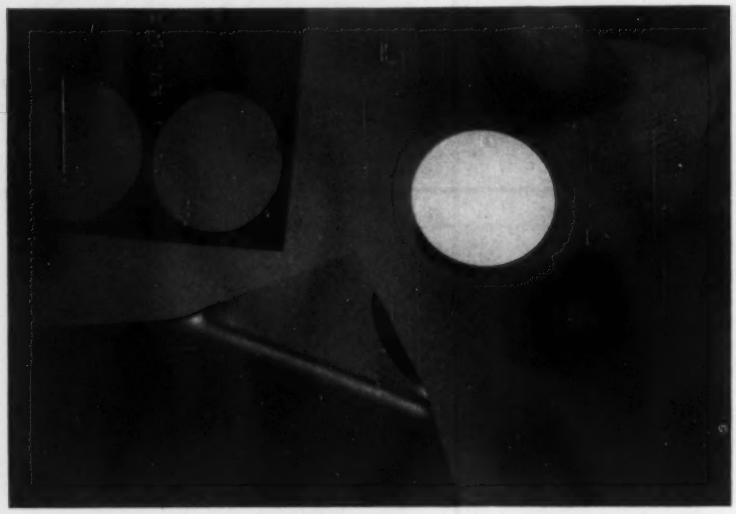
■ Recent advances in the technology of sheet rolling have enabled the Lamp Metals and Components Dept., General Electric Co., Cleveland 12 to announce a new series of clad molybdenum sheets. The sheets are clad with either copper or nickel; base metal is GE's HD molybdenum sheet (see M/DE, Sept '59, p 133).

Use of the clad sheet will eliminate the problems usually associated with plated molybdenum (blistering, flaking, or peeling), especially during punching or forming operations, and processing at high temperatures.

Clad molybdenum sheet is expected to be used extensively in semiconductor products, such as silicon power rectifiers. Molybdenum has a coefficient of expansion approaching that of silicon, and brazed moly-silicon joints expand and contract at almost the same rate, reducing the possibility of fatigue failure of the joint. Cladding the molybdenum with nickel or copper reduces the problem of brazing or soldering the molybdenum disk to other parts of the rectifier. Clad molybdenum sheet may also be used in electronic tube applications.

The sheet is available in widths up to 4 in. and in thicknesses ranging from 0.010-0.080 in. Thickness of the cladding ranges from 0.005 to 0.001 in. If demand develops, GE says, silver and gold-clad molybdenum sheets will also be produced.

For more information, circle No. 606



***Nickel-clad molybdenum** sheet has been punched and bent 90 deg without breakdown of the cladding material.*

MORE WHAT'S NEW IN MATERIALS

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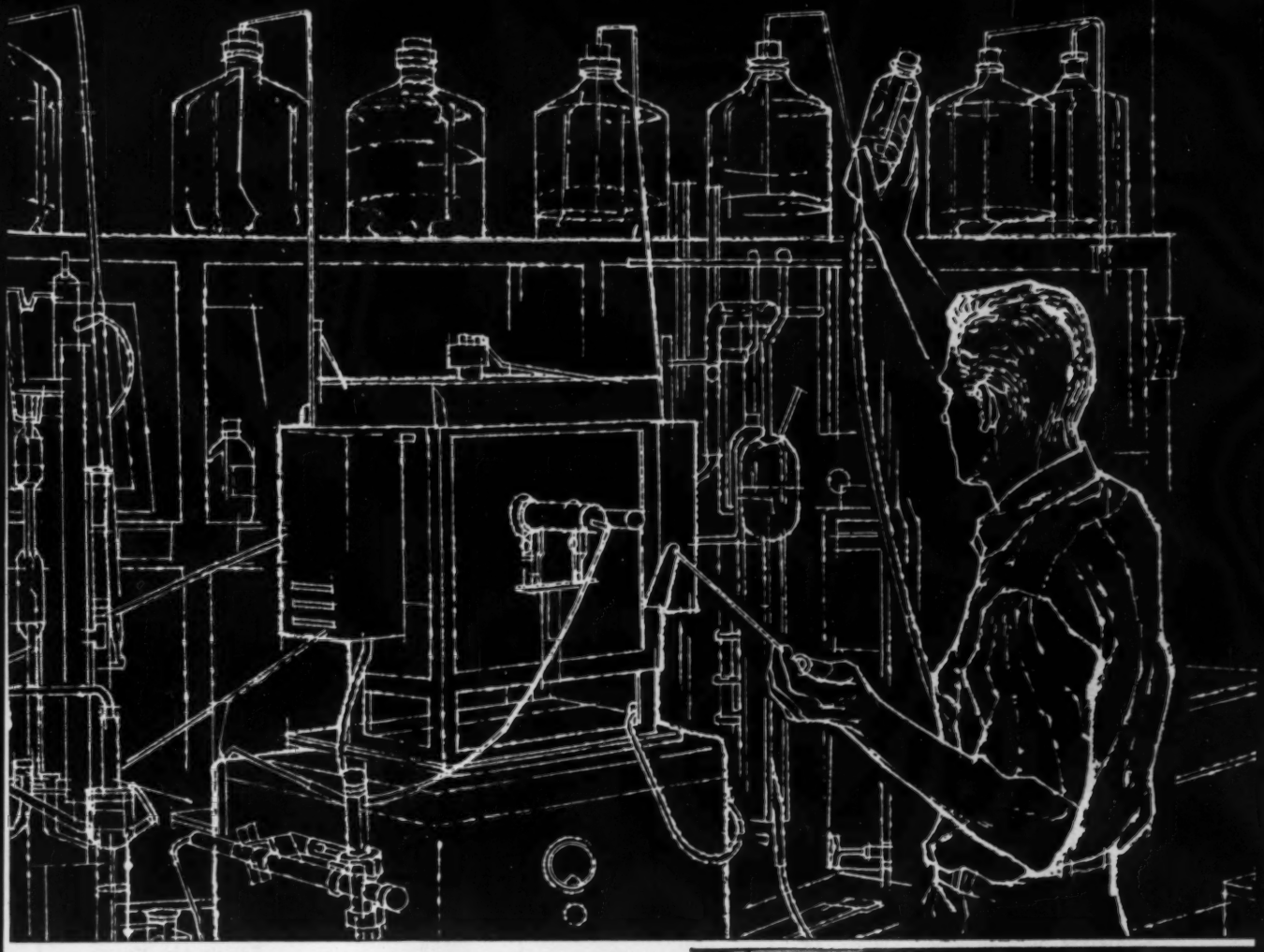

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Let's have some destructive tests

To the Editor:

Although I fully agree with G. K. Manning's editorial "Let's Stop Over-Designing" (Nov '59, p 118), I cannot resist making a few comments on product evaluation.

Recent purchases indicate serious faults in testing techniques used by some major firms. For example, some purchased products have literally fallen apart after brief, normal use; other products have functioned only sporadically. This indicates an over-reliance on statistical quality control techniques. If more suppliers would really test a few of their products to destruction, this might show them where actual strengths, over-strengths and weaknesses exist in their products.

With this proviso, then, we could agree to a program for reducing over-design. After all, it's not too costly to be old-fashioned and really see if a product will hold up under actual service conditions.

G. C. BEISHLINE
Engineer
Tilton & Cook Co.
Leominster, Mass.

Forgings vs die castings

To the Editor:

With respect to your article on "Die Castings" (Manual No. 163, Oct '59, p 113), we believe it would be well to correct the statement on p 121, col 2, line 20 which says: "In some cases brass die castings have replaced brass forgings because they can be made with greater accuracy, more complexity and thinner sections."

We object in particular to the statement ". . . because they [brass die castings] can be made with greater accuracy . . ."

Brass forgings are generally held to closer tolerances than brass pressure die castings. The usual dimensional tolerances for brass forgings up to 2 lb in weight are ±0.008 in.; however, on some types of forgings certain dimensions can be held to ±0.005 in. when necessary. A draft of 1 to 5 deg is normally used depending on the design of the forging; however, under certain conditions no draft is required.

The usual limits on brass pressure die castings are ±0.010 in. As cores wear and oxides build up on die surfaces, redressing of the die is required and there are corresponding changes in the size of castings, sometimes requiring tolerances in excess of ±0.010 in. in order to achieve normal die life and maximum productivity.

For die casting in brass, draft on cores and side walls is usually from 1 to 7 deg, although cases occur where the casting shrinks away from the die wall, in which case less draft can be used. It is best, however, to allow greater draft when conditions permit

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as core and die wall wear can be reduced and easier ejection results, thus avoiding a tendency for the ejector pin to distort or mar the castings.

Other statements in the sentence are correct, since it is true that brass die castings can be made with greater complexity and thinner sections.

M. J. MIANULLI
Manager
Customer Service Dept.
Titan Metal Mfg. Co.
Bellefonte, Pa.

Sodium silicate impregnants

To the Editor:

With respect to the article "Impregnants for Castings" (Oct '59, p 102), I would like to point out that sodium silicate develops peculiar and useful properties because it is much more than a "dispersion of droplets of sodium silicate" as stated in the article. This description is incorrect, and gives the impression that sodium silicate is an organic compound emulsified in water. Actually, sodium silicate is an alkaline, aqueous solution of sodium and silicate ions with most of the ions polymerized into charged colloidal particles of widely varying size. These colloidal particles, according to the system in which they are being used, protect against corrosion, dry out to a solid film, and/or polymerize further into a space filling gel.

Furthermore, the statements on sodium silicate in the article are misleading in suggesting that sodium silicate will cause corrosion at the concentration and ratio of silica to alkali used in sealing castings. As a matter of fact, sodium silicate protects iron, aluminum, magnesium, copper, brass, bronze and other ferrous and nonferrous castings against corrosion.

Large quantities of sodium silicate are now widely used for impregnating castings as they have been for many years past with general satisfaction.

JOHN H. WILLS
Philadelphia Quartz Co.
Philadelphia

Help needed on plating tellurium

To the Editor:

We are interested in finding a process for electroplating tellurium onto other metals.

A. B. CARVER
Senior Engineer
Applied Physics Laboratory
John Hopkins University
Silver Spring, Md.

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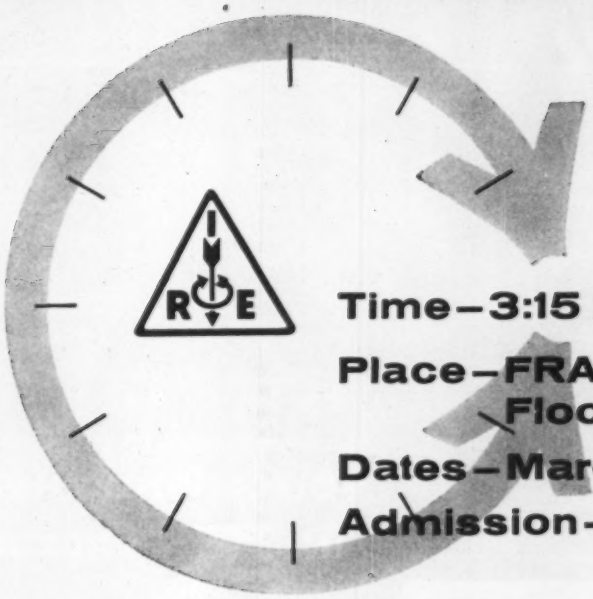
Don't miss this special report at the IRE Show...

NEW DEVELOPMENTS IN HIGH-TEMPERATURE DIELECTRICS

A comprehensive lecture-demonstration
by the engineering staff of Mycalex Corporation of America



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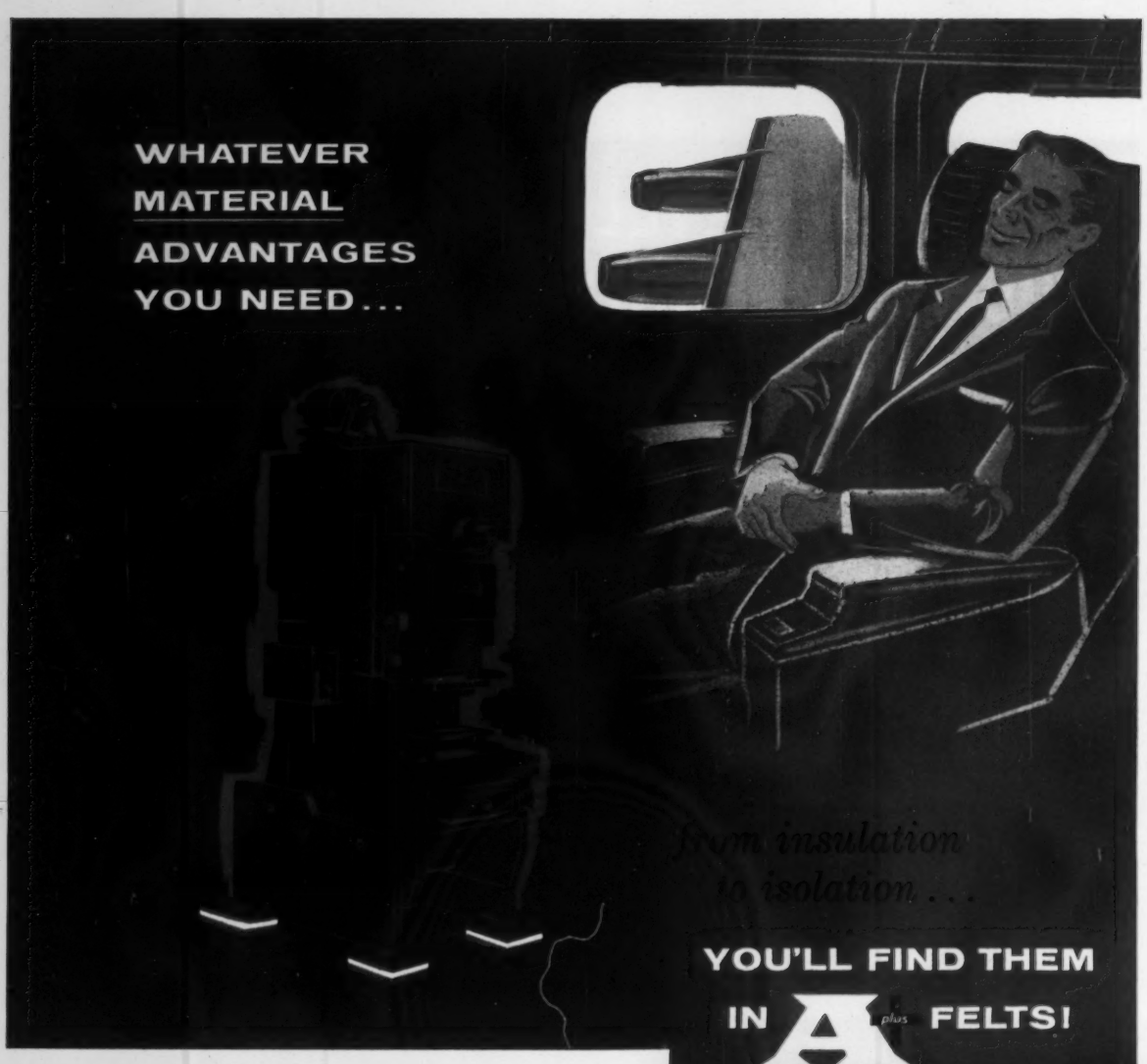

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Among our famous trademarks: **VISTEX**—fiber-reinforced gaskets and seals; **WINDSOR FELT**—nonwoven bonded fabrics; **HUSHALON**—decorative and acoustical wall covering.

American Felt Company

For more information, turn to Reader Service card, circle No. 394

PRICES & SUPPLY

...AT A GLANCE

Commercial production of FEP fluorocarbon resin has been announced by Du Pont. Price of the new resin, called Teflon 100, is $11.60 per lb in truckload quantities. Teflon FEP fluorocarbon resin was introduced in late 1956 (see *Materials & Methods*, Nov '56, p 161, and M/DE, Apr '58, p 171). Teflon FEP film was introduced late last year (see M/DE, Dec '59, p 131).

Foreign steel imports increased 150% in 1959 over 1958, according to the American Iron and Steel Inst. Imports totalled 4.4 million tons. And volume of foreign steel imports will continue to be high in the 60's, says John F. Smith, Jr., president of Inland Steel Co. Reason: 1) price advantages, 2) quality competition, and 3) the possibility of continued use of foreign steel by American consumers who used it for the first time during the strike.

An increase in butyl rubber production from 97,500 long tons to more than 135,000 long tons per year was announced recently by Enjay Co., Inc.

A price reduction on semiconductor-grade indium metal has been announced by Consolidated Mining & Smelting Co. of Canada Ltd. New price is $16 per troy oz in 5 to 199-troy oz lots, down $6 per oz.

More melamine and urea molding compounds will be available late this year when production facilities at Allied Chemical Co.'s Toledo, Ohio plant will be doubled. The expanded facilities will raise Allied Chemical's total melamine and urea production capacity to 45 million pounds.

Iron powder production set a new record of 35,000 tons in 1959, compared to 22,500 tons produced in 1958, according to the Metal Powder Producers Assn. Copper and copper-base powders also set a record of 25,000 tons in 1959.

Another price reduction for fluorosilicone rubber, the fifth since the material's introduction in 1956, has been announced by Dow Corning Corp. New price is $12 per lb, down 25% from a previous price of $16 per lb. Materials affected by the price cut are Silastic LS-53 and LS-63 stocks, and Silastic LS-422 masterbatch. (The three materials are described in the Feb '60 issue of this magazine, p 13.)

A 35% boost in galvanized steel sheet production was announced recently by Inland Steel Co., which is adding a fourth continuous galvanizing line to three already in operation. The new line, scheduled for completion in early 1961, will coat coils up to 60 in. wide, and will have a rated capacity of 120,000 tons per year.

A new producer of polypropylene fiber is Industrial Rayon Corp. of Cleveland. The company plans semicommercial production of its "Prolene" staple fiber, tow and continuous filament yarns later this year.

Current Prices of Materials on p 211

in only 90 days...

101 aluminum fabricators have ...Amchem's newest

ALODINE 1200S protects aluminum best ...at less cost, in less time!

To the hundreds of long-time users of Amchem Alodine—the first, low cost effective surface conversion treatment for aluminum—add a new host of fabricators who are employing the newest Alodine development—ALODINE 1200S!

If you are producing aluminum—any type of aluminum—you'll want to investigate the production advantages and profit potentialities of this new Alodine pre-paint process that provides constant, uniform quality as well as big savings in time, equipment and processing costs!

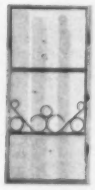
Through increased chemical activity ALODINE 1200S slashes processing time *up to 50 percent!* A 1200S system can be installed on your production line quickly and conveniently . . . and bath is maintained chemically . . . no special equipment required to control contamination! In an ALODINE 1200S system, products can be processed through continuous dip in the same time cycle other conversion coatings require for continuous spray lines! That means lower initial equipment and maintenance costs, wider range of product applications regardless of the application method—brush, dip, continuous strip or spray. ALODINE 1200S is qualified under Government Specification MIL-C-5541.

ALODINE 1200S is Amchem's positive answer to constant uniform quality in aluminum processing. Put its assured protection and production flexibility to work for your aluminum products and market them with greater confidence!

switched to Alodine 1200S conversion coating!

FASTER, LOW COST, EFFECTIVE AND FLEXIBLE, ALODINE 1200S IS PROVIDING NEW HIGHS

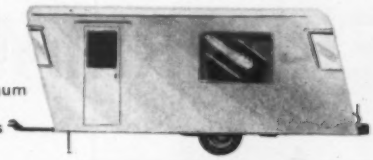
aluminum stop signs

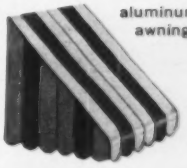

aluminum doors

aluminum venetian blinds

IN CORROSION RESISTANCE AND PAINT BONDING QUALITIES TO THESE AND

aluminum cameras


aluminum house trailers


aluminum awnings

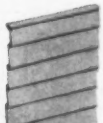
MANY MORE FINE PRODUCTS IN THE ALUMINUM INDUSTRY. YOU, TOO, CAN

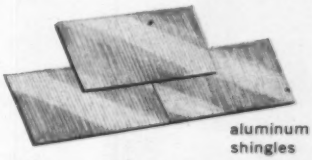
aluminum boats

aluminum license plates

aluminum missile parts

UPGRADE YOUR PRODUCTS' CONSUMER APPEAL WITH ALODINE PROTECTION.


aluminum siding


aluminum shingles

aluminum mail boxes

CONTACT YOUR NEAREST AMCHEM REPRESENTATIVE FOR COMPLETE DETAILS!

AMCHEM

ALODINE 1200S

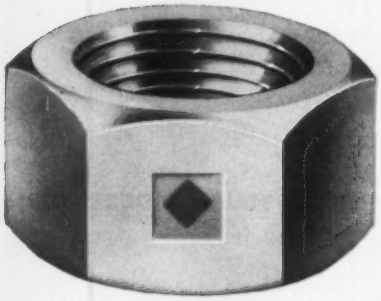
Amchem and Alodine are registered trademarks of **AMCHEM PRODUCTS, INC.**

(Formerly American Chemical Paint Co.)

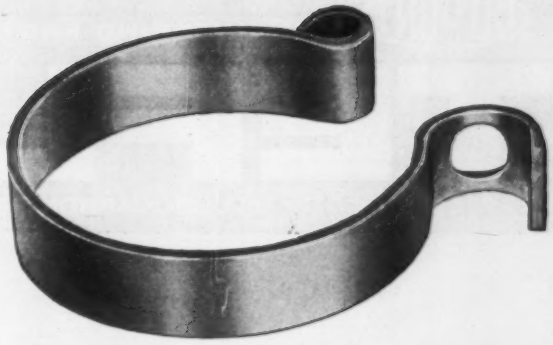
AMBLER, PA. • Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont.

For more information, turn to Reader Service card, circle No. 436

PERFORMANCE UP...

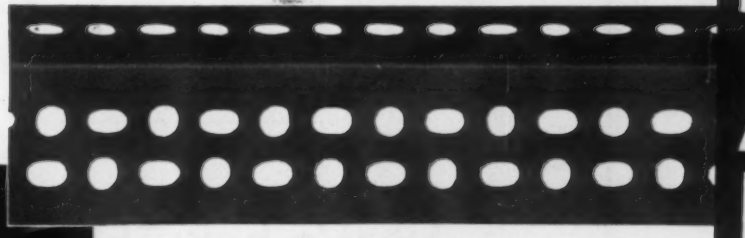


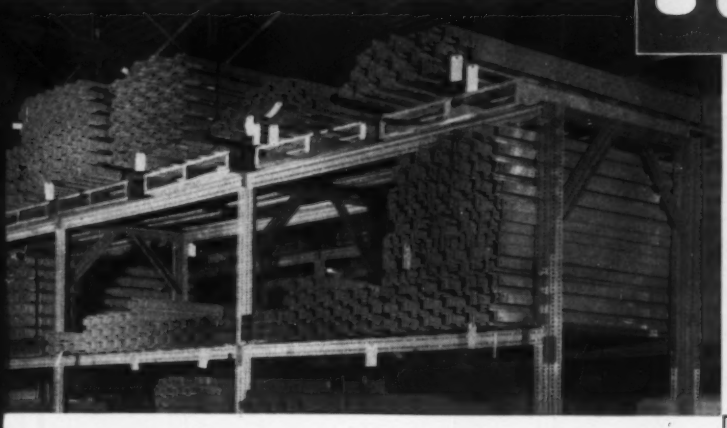
ROBERTON MANUFACTURING COMPANY, Chicago, Illinois, uses 44 Republic NYLOK® Self-Locking Fasteners to hold power units firmly in place in their Roberton Twin Power Riding Mowers. NYLOK'S special nylon inserts assure positive locking in any position. Displacement of the insert produces strong lateral pressure, preventing any play despite extreme vibration.



ACME STAMPING & WIRE FORMING COMPANY, Pittsburgh, Pennsylvania, uses Republic Type 302 Stainless Steel in the production of tough, corrosion-resistant friction bands for outboard motors produced by- Evinrude Motors, Milwaukee, Wisconsin. Used on pivot shafts, the bands measure .062" x 15/32". Fabricating operations include punching, forming in a four slide machine, and brazing on the loop end. According to Acme, ENDURO® Stainless Steel supplied by Republic is exceptionally uniform . . . assures higher product quality at lower unit cost.

COST DOWN





MORE AND MORE COMPANIES are using Republic METAL LUMBER® to save time and money in meeting storage requirements. Short slots, placed to allow ¾" vertical adjustment, offer unlimited applications. You simply plan, measure, cut, and assemble. METAL LUMBER is Bonderized. Steel resists damage and permits maximum loading. Send for complete details.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

For more information, turn to Reader Service card, circle No. 363

REPUBLIC STEEL CORPORATION
DEPT. ME-8713
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on:

☐ Republic Stainless Steel
☐ NYLOK Self-Locking Fasteners
☐ Republic METAL LUMBER

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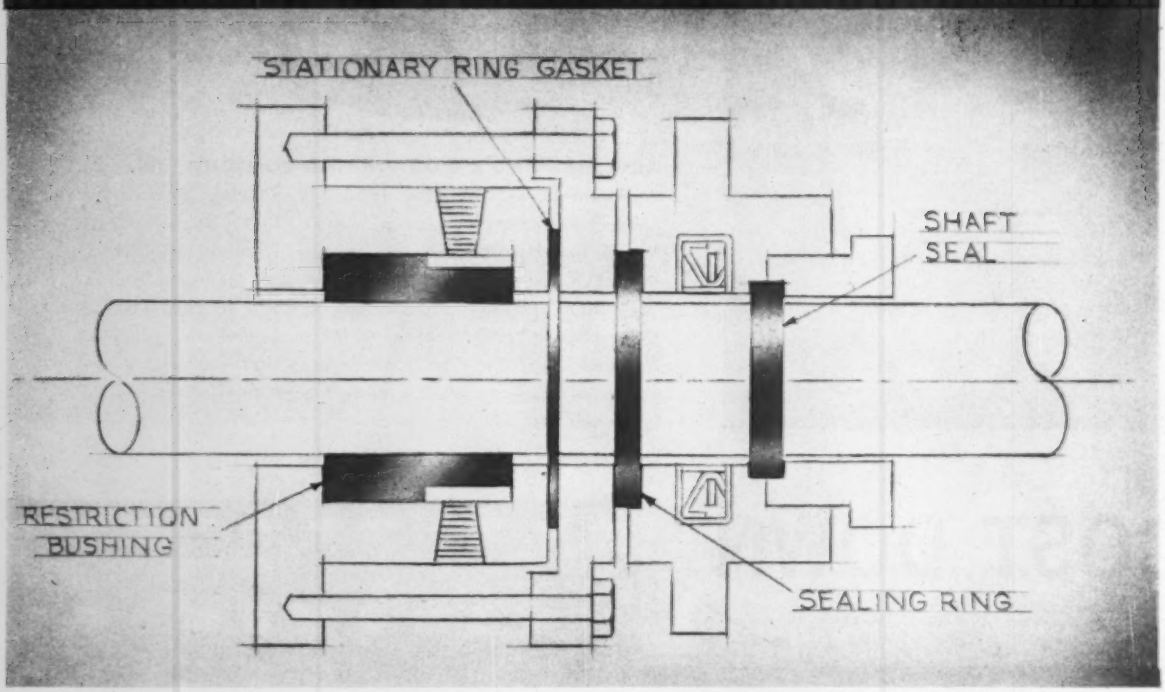
DU PONT

ENGINEERING FACTS ABOUT

TEFLON®

FLUOROCARBON RESINS



Here's how TEFLON® TFE resins improve your mechanical seals

The unique properties of TEFLON TFE fluorocarbon resins as sealing materials are particularly pertinent to the design of mechanical seals. The use of TFE resins at the heart of these seals provides, in even greater measure, the very same advantages which have led to the widespread and growing acceptance of mechanical seals in pumps, agitators, motors and many other types of machinery.

The advantages of mechanical seals include savings in both materials and labor for repacking and packing adjustment. They eliminate wear on the shaft. They greatly reduce leakage and eliminate loss of product. They enhance safety in the handling of toxic or flammable materials.

The advantages of TFE resins in mechanical seals include savings in replacement and maintenance costs because of their long life and interchangeability in being able to handle almost all chemicals. Their natural lubricity and ability to embed hard foreign particles without damage greatly reduce shaft wear. They produce tight, lasting seals to eliminate leakage. TFE resins are completely inert to virtually all chemicals and solvents, and they maintain their superior properties under a wide temperature range.

For further information on the properties and design characteristics of TFE resins for use in shaft seals, sealing rings, stationary ring gaskets, restriction bushings and other sealing applications, consult your local supplier or write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept. T-263, Room 2526, Wilmington 98, Del.

In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Que.

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

DU PONT TEFLON®
TFE-FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

For more information, turn to Reader Service card, circle No. 417

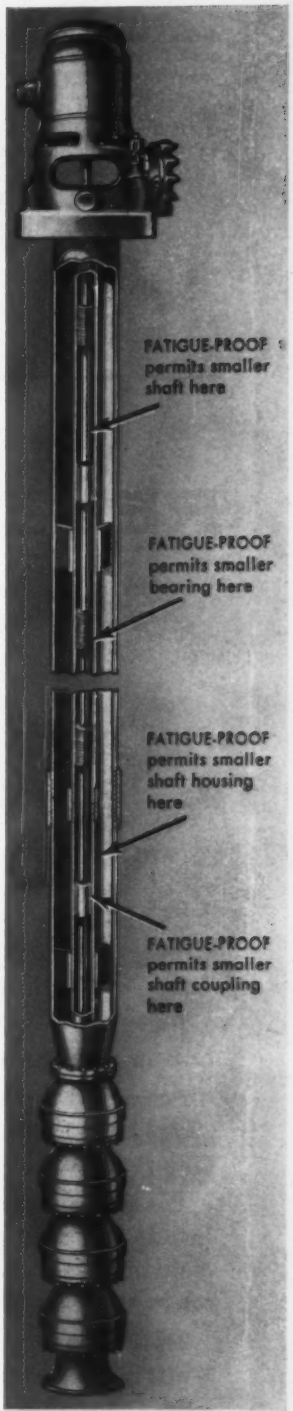
Salt River Valley Water Users Association,
Phoenix, Arizona

Saves $699.00 per pump...

by using ground and polished

fatigue-proof®
STEEL BARS
e.t.d.

made by elevated temperature drawing process


FATIGUE-PROOF permits smaller shaft here
FATIGUE-PROOF permits smaller bearing here
FATIGUE-PROOF permits smaller shaft housing here
FATIGUE-PROOF permits smaller shaft coupling here

The men who operate the "Salt River" project have the job of supplying water to 240,000 acres of land in Arizona, where the Gila River joins the Salt River. The Association maintains some 250 deep well pumps to help supply the required water.

Richard Juetten, Supervisor of Salt River's Pump Division, reports that the use of La Salle FATIGUE-PROOF steel bars has permitted a saving of $699.00 per pump . . . a potential saving of $174,750 when applied to the 250 pumps now in operation.

Mr. Juetten's report follows:

"I have figured our direct saving realized by using La Salle FATIGUE-PROOF steel bars in place of standard C-1045 steel shaft in our deep well turbine pumps.

"FATIGUE-PROOF enables us to use bars only $1\frac{11}{16}$" in diameter . . . instead of $2\frac{3}{16}$" diameter shafts which were necessary when we used C-1045 . . . and this despite higher horsepower, more weight, and additional pump bowl assemblies.

"Here are comparative costs per 10-foot section (of a 300-foot pump shaft):"

using C-1045		using FATIGUE-PROOF	
10' x 2-3/16" dia. shaft	$28.30	10' x 1-11/16" dia. FATIGUE-PROOF	$22.59
3½" shaft housing	26.30	3" shaft housing	19.80
2 bearings, 3½" x 2-3/16"	21.72	2 bearings, 3" x 1-11/16"	13.46
Shaft coupling	5.16	Shaft coupling	2.34
TOTAL cost	$81.48	TOTAL cost	$58.19
Cost per foot	$ 8.15	Cost per foot reduced to	$ 5.82

RESULT: A saving of $2.33 per foot . . . or $699.00 when applied to a 300-foot pump setting. And this doesn't take into consideration reduced power consumption.

La Salle STEEL CO.
1418 150th Street
Hammond, Indiana

ASK FOR 24-PAGE BOOKLET—It tells the complete story of FATIGUE-PROOF®

name_____

title_____

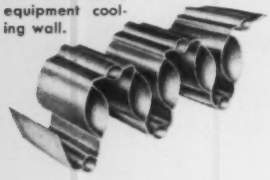
company_____

address_____

city and zone_____ state_____

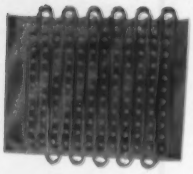
Mail to La Salle Steel Company, 1418 150th Street, Hammond, Indiana

For more information, turn to Reader Service card, circle No. 403

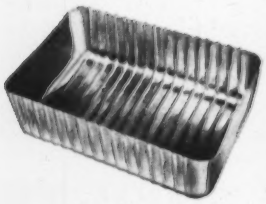


Section of Aluminum Tube-In-Strip combining refrigerant passages with air cooling for electronic equipment cooling wall.

Copper Tube-In-Strip used as a combustion chamber for water heater.



Copper Tube-In-Strip with return bends attached to produce a cooling plate.



This electronic cooling case of Revere Aluminum Tube-In-Strip was inflated after drawing.

REVERE *Tube-In-Strip* SCORES

NOW USED AS WATER-COOLED BUS BAR in manufacture of General Electric Semiconductor Rectifiers

HAS THESE 4 BIG MONEY-SAVING ADVANTAGES

1 Because it is a homogeneous mass Revere Tube-In-Strip eliminates the possibility of leaks.

2 User is able to obtain more efficient cooling.

3 If user finds it necessary to change cells it can be done without draining the system.

4 Revere Tube-In-Strip enables user to have a completely sealed system, thus eliminating O-rings or gaskets.

The use, by General Electric, of Revere Tube-In-Strip as water-cooled bus bar is still another of the myriads of ways this revolutionary product can be applied in industry.

The unique thing about Revere Tube-In-Strip is that it is a solid piece of metal, not two strips welded, brazed or bonded together. You buy strip, fabricate it as you wish, stamping, bending or forming it, and then as a final operation inflation expands the integral channels into tubes. Expanding in the open, the tubes are round; by expanding into dies, the tubes can be made rectangular, fluted, half-round, hexagonal, etc.

Revere Tube-In-Strip saves on first cost, and in fabrication. New and improved designs are made possible. The web between the tubes conducts heat faster. The vastly increased structural strength means you can use lighter gauges, saving in weight and price.

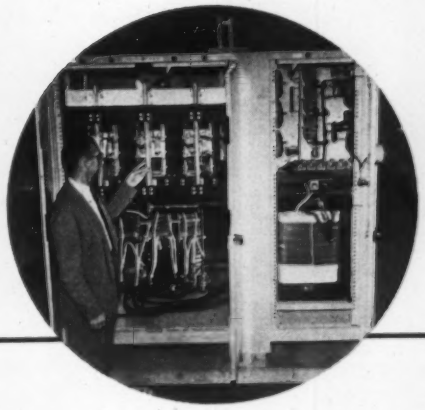
Revere Tube-In-Strip is available in Copper, Copper-base alloys and Aluminum alloys. The Revere Technical Advisory Service and the Research and Development Department will gladly collaborate with you in taking full advantage of this marvelous new material.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.

Mills: Rome, N. Y.; Baltimore, Md.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; Ft. Calboun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

Copper Tube-In-Strip spiral containing both water and refrigerant passages for increased cooling efficiency.

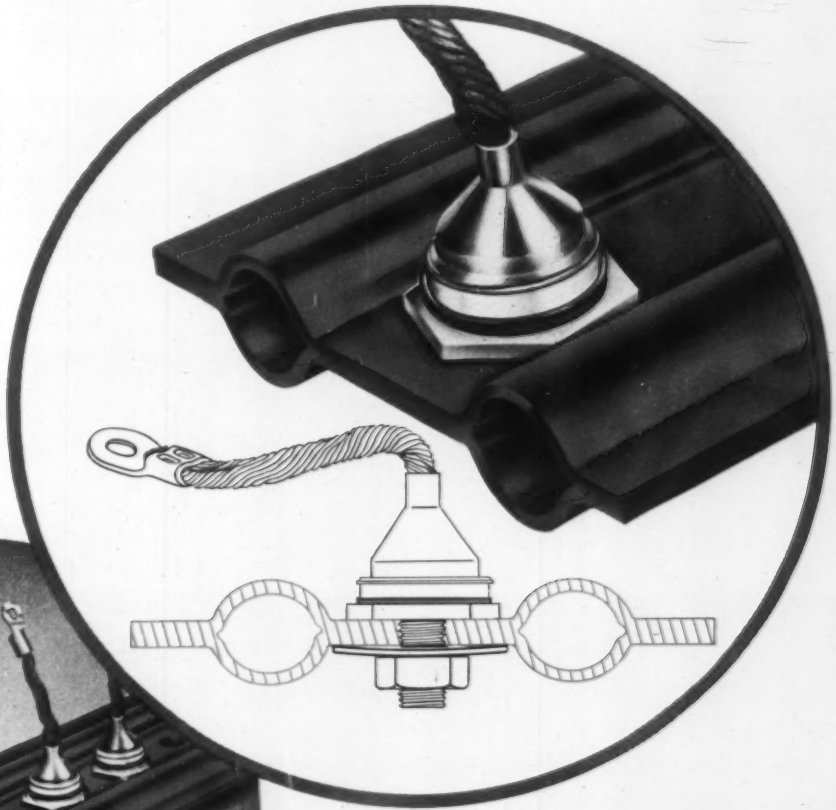


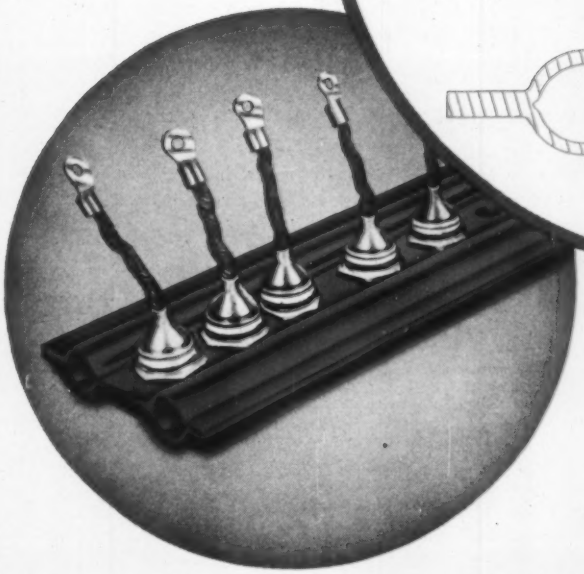
Copper Tube-In-Strip and finned stock assembled and then inflated into automotive air conditioning coil.

Copper Tube-In-Strip and copper fin assembly for automobile radiator.

ANOTHER TRIUMPH!

PHOTO IN CIRCLE ABOVE SHOWS water-cooled semiconductor power rectifier design with integrally mounted transformer as made by General Electric Company. Rated 150 volts, 4000 amps., d-c, it is used for copper refining.





(Above) **CROSS SECTION** of water-cooled bus, featuring improved cooling method. Dual, leak-proof water passages are formed in solid bus, made from Revere Tube-In-Strip, without the need for welding or brazing. They are located on each side of a section of bus to which silicon cells can be bolted without penetrating the coolant passages.

(*Left*) **OVERALL VIEW** of new sealed liquid-cooled bus illustrating manner of mounting several silicon rectifier cells. Unique "dry" mounting permits installation of cells without draining liquid from bus. Cells are individually attached to the bus with threaded stud and nut, simplifying the mounting of a cell, and making it unnecessary to disturb any of the other cells on the bus.

For more information, turn to Reader Service card, circle No. 383

SPAULDING *800* ROD

Puts More "Skill" in Electric Skillets

Thanks to this tiny insulation pin, housewives now get exact temperature control in their cooking appliances because manufacturers are able to design a better product.

It's made of Spaulding 800 Rod material and used in the temperature control dial of electric fry pans.

Spaulding 800's extremely high dimensional stability under heavy moisture conditions helps the dial maintain factory-set temperature calibration and control indefinitely.

800 is another example of a new material developed through the research facilities at Spaulding to meet the changing needs of industry.

Progress Reports on other new Spaulding materials are available on request.

Spaulding 800 Offers These Unique Characteristics

ELECTRICAL GRADES	XXX-800 (Paper Base)	LE-800 (Linen Base)
Diameter Tested	¼"	¼"
Water Absorption %	.46	.42
Specific Gravity	1.35	1.37
Flexural Strength PSI	28,000	26,000
Tensile Strength PSI	16,700	21,000
Compressive Strength Axially	24,000	30,000
Charpy Impact Strength Ft. Lbs.	.25	.38

SPAULDING FIBRE COMPANY, INC.

344 Wheeler Street, Tonawanda, New York

For more information, turn to Reader Service card, circle No. 369

For more information, circle No. 449 ➤

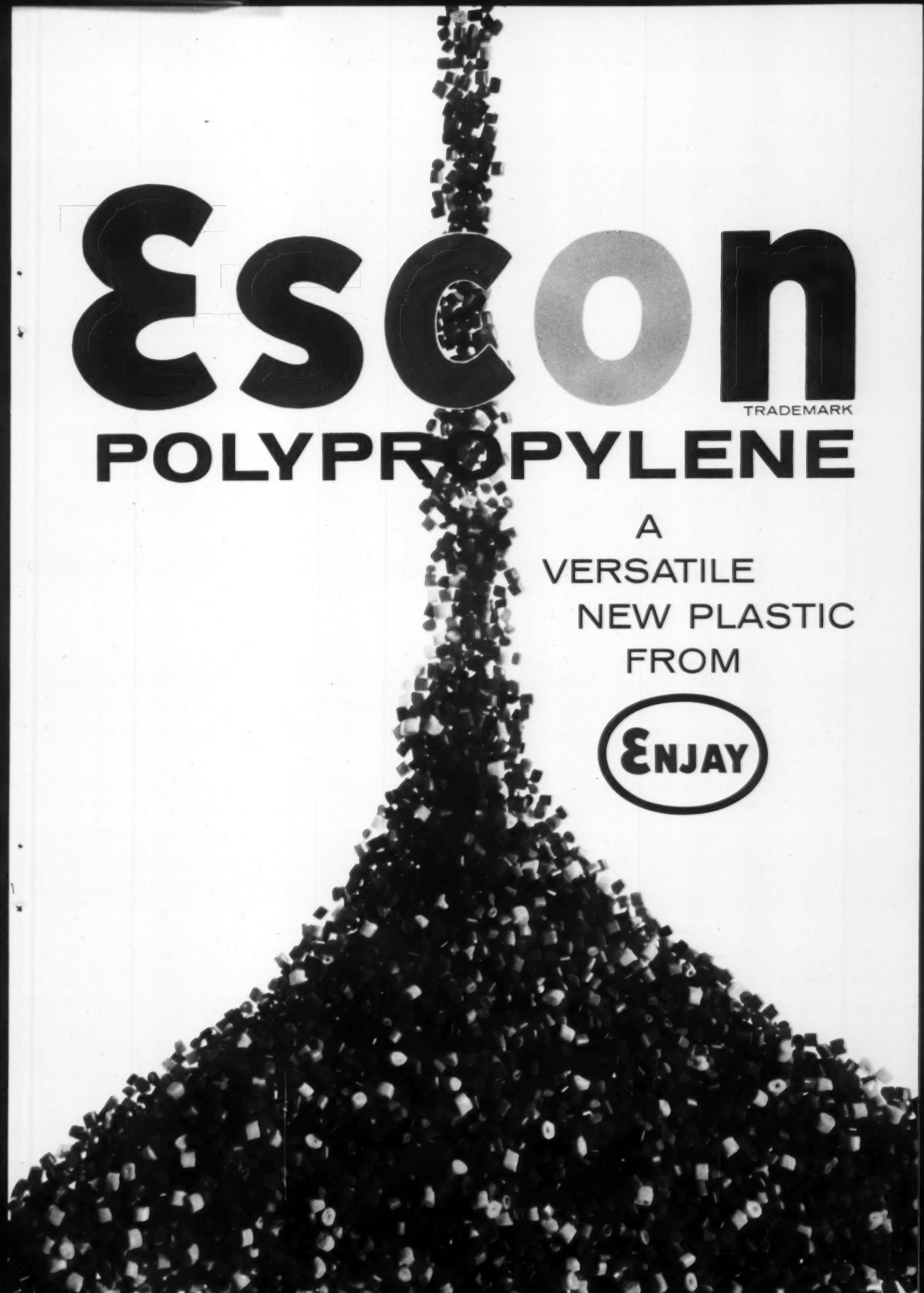
Escon

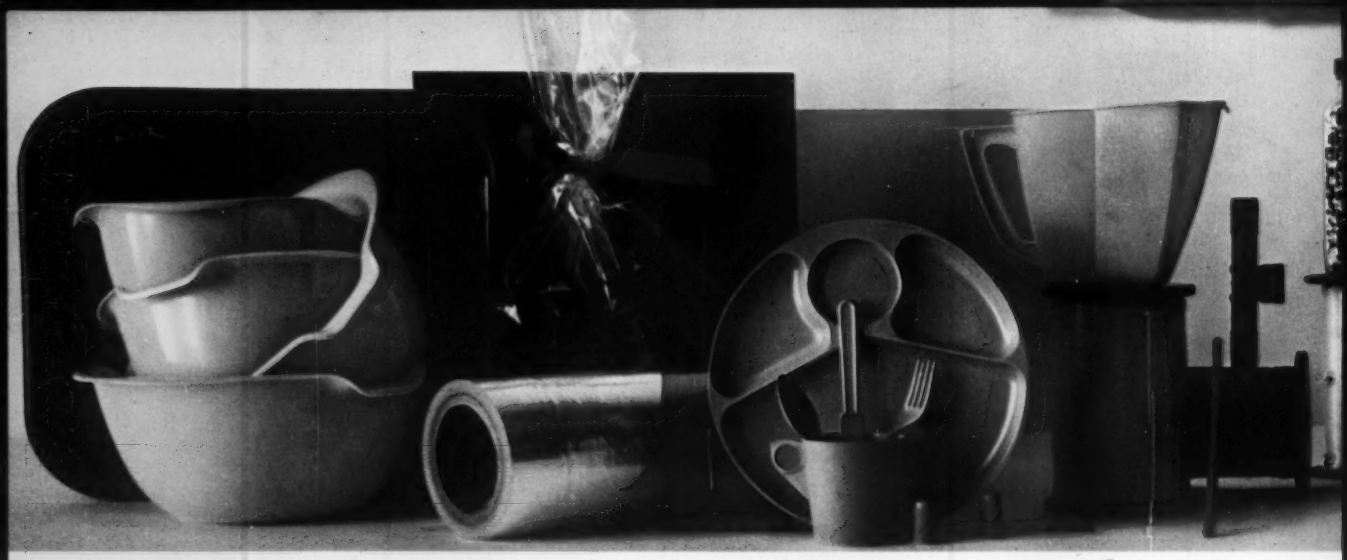
TRADEMARK

POLYPROPYLENE

A
VERSATILE
NEW PLASTIC
FROM

ENJAY





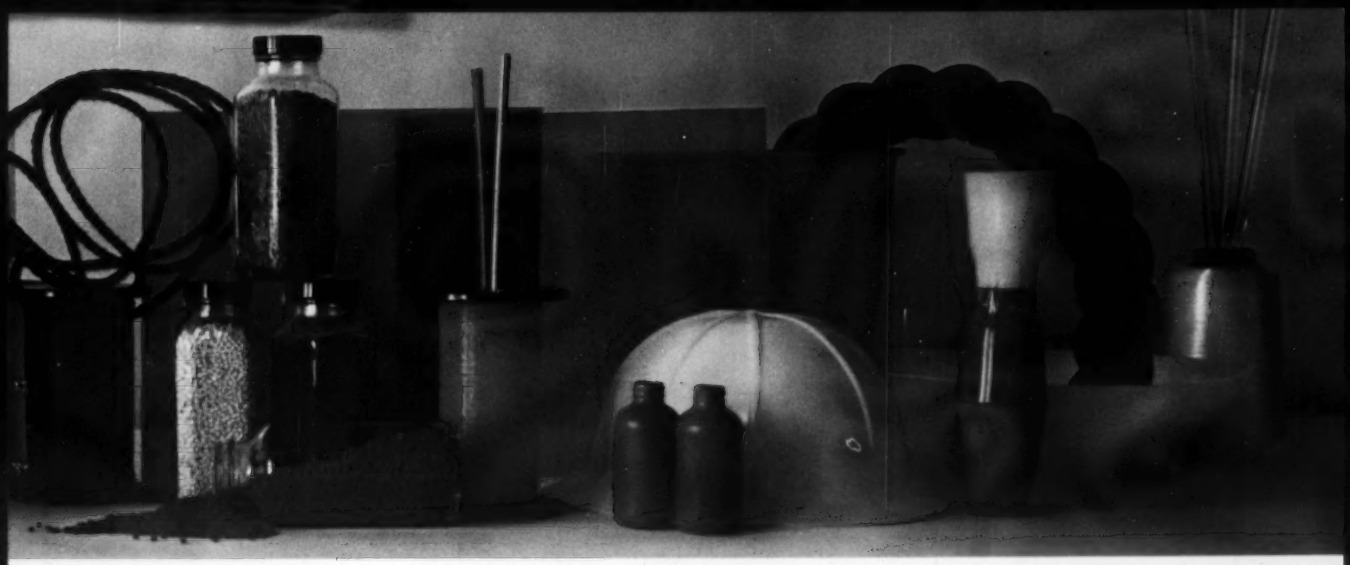
Specify ENJAY Escon

TRADEMARK

This new thermoplastic resin is the world's lightest plastic. Yet it provides excellent strength and rigidity. It can be made in brilliant lasting colors with high surface gloss and hardness. Escon also offers outstanding resistance to chemicals and stress cracking. Versatile Escon can be fabricated in a wide variety of ways. For example, it can be injection

FOR PACKAGING. Escon film can be produced by water bath or chill roll technique with extreme clarity and gloss. It offers greater heat resistance than any other polyolefin and can be sterilized by heat or chemical means. In addition, Escon offers excellent stiffness and toughness. Escon clear film can be color printed on either side — or both sides — for extra eye and buy appeal.

FOR MOLDING. Because of its light weight, Escon yields more pieces per pound. In injection molding, Escon's high strength plus its unique chemical and abrasion resistance makes it suitable for the manufacturing of many consumer products. Escon also allows accurate reproduction of fine and intricate designs with high surface lustre.

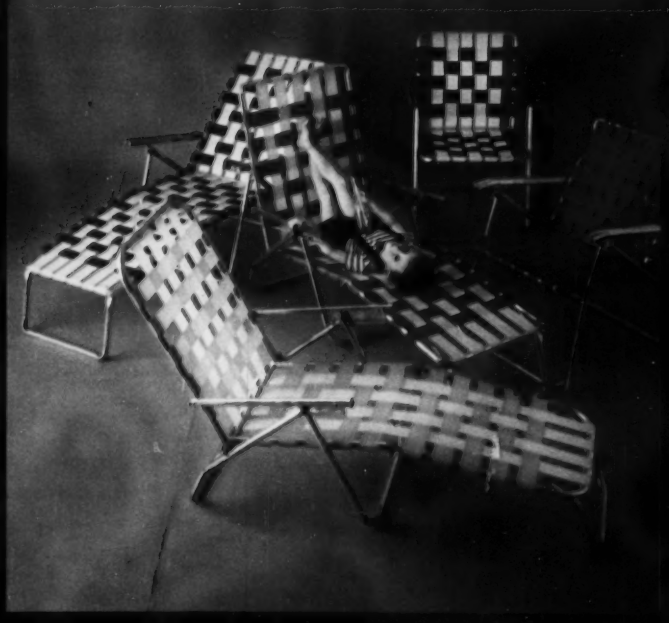


polypropylene for new beauty, utility and economy

molded; extruded into film, sheet and shapes. It can also be drawn and vacuum formed, heat sealed, machined and printed. Because of the rigid manufacturing standards of the Enjay Company, molders and designers are assured of high uniform quality whenever they specify Escon polypropylene. Versatile Escon can be tailor-made to meet a variety of product needs.

FOR EXTRUDING. Escon may be extruded in an almost unlimited range of thicknesses and forms. Its excellent physical and chemical properties make it an ideal plastic for such operations as thermoforming, punching, machining, die cutting and welding. Surface details are accurately reproduced too. And pigmentation, before or during extrusion, produces brightly colored sheet stock.

FOR FIBERS AND MONOFILAMENTS. Escon allows more yards of fiber per pound. Its high tensile strength, good knot strength and resilience, plus its immunity to attack by fungus, moths and marine organisms make it ideal for ropes and woven fabrics. Escon fibers show excellent wet strength, wet flexing durability, and abrasion resistance maintained to minus 70°F.



Escon

TRADEMARK

OFFERS A UNIQUE COMBINATION OF OUTSTANDING PROPERTIES

Various grades of Escon are offered to permit the processor to choose the grade best suited to his needs. Values for properties tabled at right will vary depending upon how the sample is formed and treated. Ask us for help on your specific requirements.

How Enjay helps you profit with Escon — Escon can help your product do a better job. To assure this, Enjay offers you complete technical assistance from one of the world's best staffed and equipped technical service laboratories. Here Enjay scientists can help you develop new products and improve existing ones through efficient use of Escon polypropylene.

To order Escon or for complete technical data, contact the Enjay office nearest you.

PROPERTY	DATA	METHOD
density, 73°F., g./cc.	0.897-0.910	ASTM D1505-57T
melt index, @250°C., g./10 min.	1-10	ASTM 1238-57T (load, 2,160g.)
environmental stress cracking (100% Igepal CD-630)	none	Bell Labs.
burning rate	slow	ASTM D635
machining qualities	excellent	
mold shrinkage, in./in.	0.015-0.030	
water absorption, %	<0.01	ASTM D570-57T
yield strength, psi, 2"/min.	3800-5100	ASTM D638-58T
tensile strength, psi, 2"/min.	3500-4900	ASTM D638-58T
yield elongation, %, 2"/min.	13-18	ASTM D638-58T
ultimate elongation, %, 2"/min.	22-315	ASTM D638-58T
Impact strength, ft.-lb./in.		ASTM D256-54T
Izod notched	1	
Izod unnotched	>16	
hardness		
Rockwell R	80-90	ASTM D785-51
Shore D	70-75	ASTM D676-55
elastic modulus, psi, 2"/min.	45,000-60,000	ASTM D638-58T
flexural modulus of elasticity, psi, 2"/min.	111,000-176,000	ASTM D790-58T
flexural modulus of rupture (flexural strength), psi, 0.05"/min. (no break-max. load)	65,000-81,000	ASTM D790-58T
compressive yield stress, psi, 0.05"/min.	5,300-6,400	ASTM D695-54
compressive strain @yield, %, 0.05"/min.	15	ASTM D695-54
compressive elastic modulus, psi, 0.05"/min.	53,000-63,000	ASTM D695-54
stiffness in flexure, psi	95,000-150,000	ASTM D747-58T
modulus of elasticity, psi	100,000-128,000	ASTM D1043-51
Taber abrasion, mg. loss/1000 cycles (CS-17 wheel, 1000g. load)	29-32	
melting point, °F.	335	polarizing microscope
vicat softening point (1 kg.), °F.	266-293	ASTM 1525-58T
deflection temperature		ASTM D648-56
°F. @264 psi fiber stress	131	
°F. @66 psi fiber stress	188	
coefficient of thermal conductivity		
cal./cm./cm.²/sec./°C.	2.80×10^{-4}	
BTU/in./ft.²/hr./°F.	1.13	
coefficient of linear thermal expansion in./in./°C.	0.00020	ASTM 696-44
specific heat @73°F., cal./g.	0.46	
ELECTRICAL PROPERTIES		
volume resistivity, ohm-cm	6.5×10^{16}	ASTM D257-54T
dielectric strength, volts/mil		
short-time, 1/8" thickness	660	ASTM D149-55T
step-by-step, 1/8" thickness	650	
dielectric constant, 10^6 cycles	2.0	ASTM D150-54T
dissipation (power) factor, 10^6 cycles	0.0002-0.0003	ASTM D150-54T

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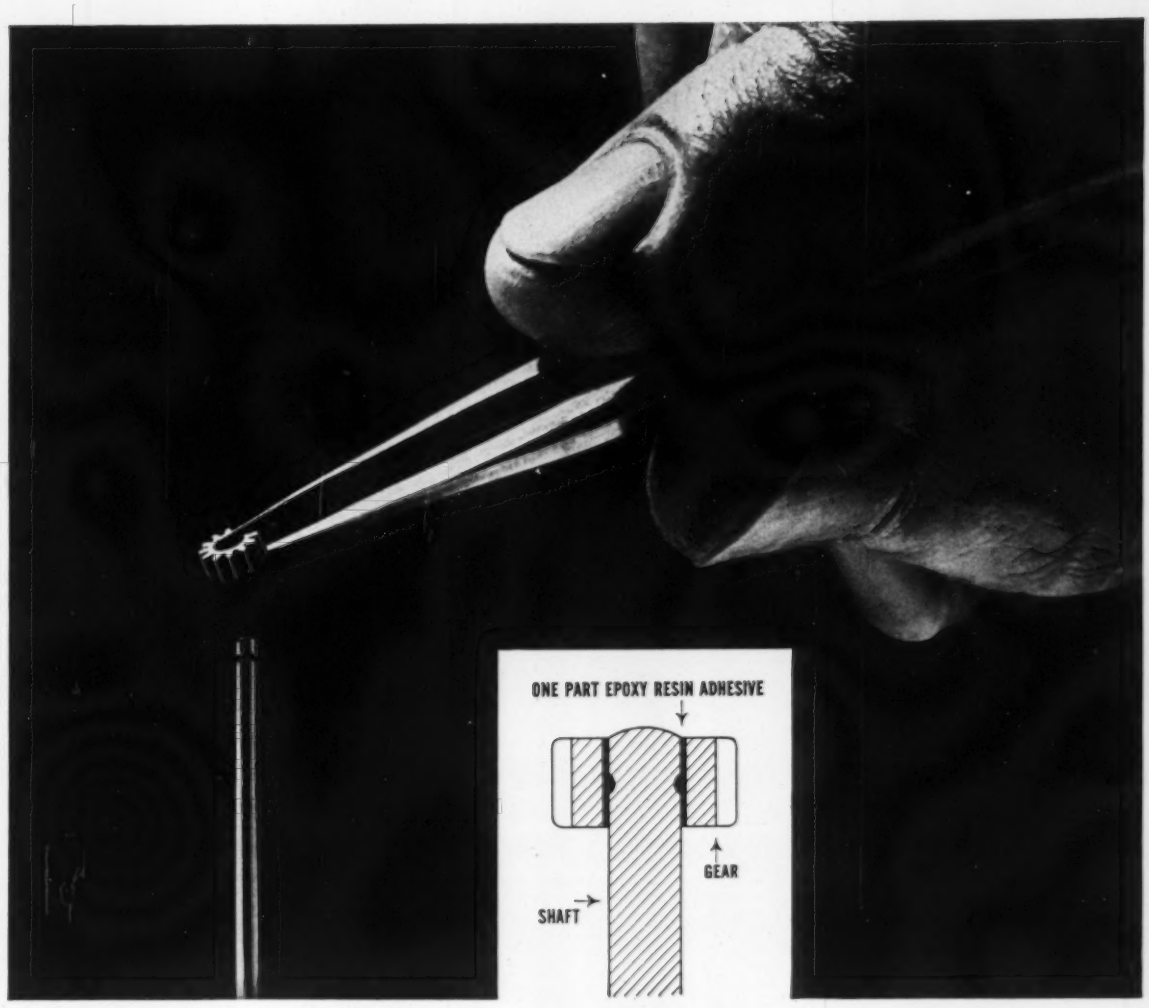

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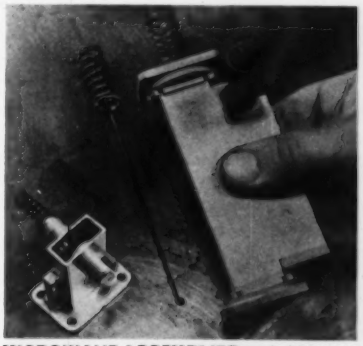

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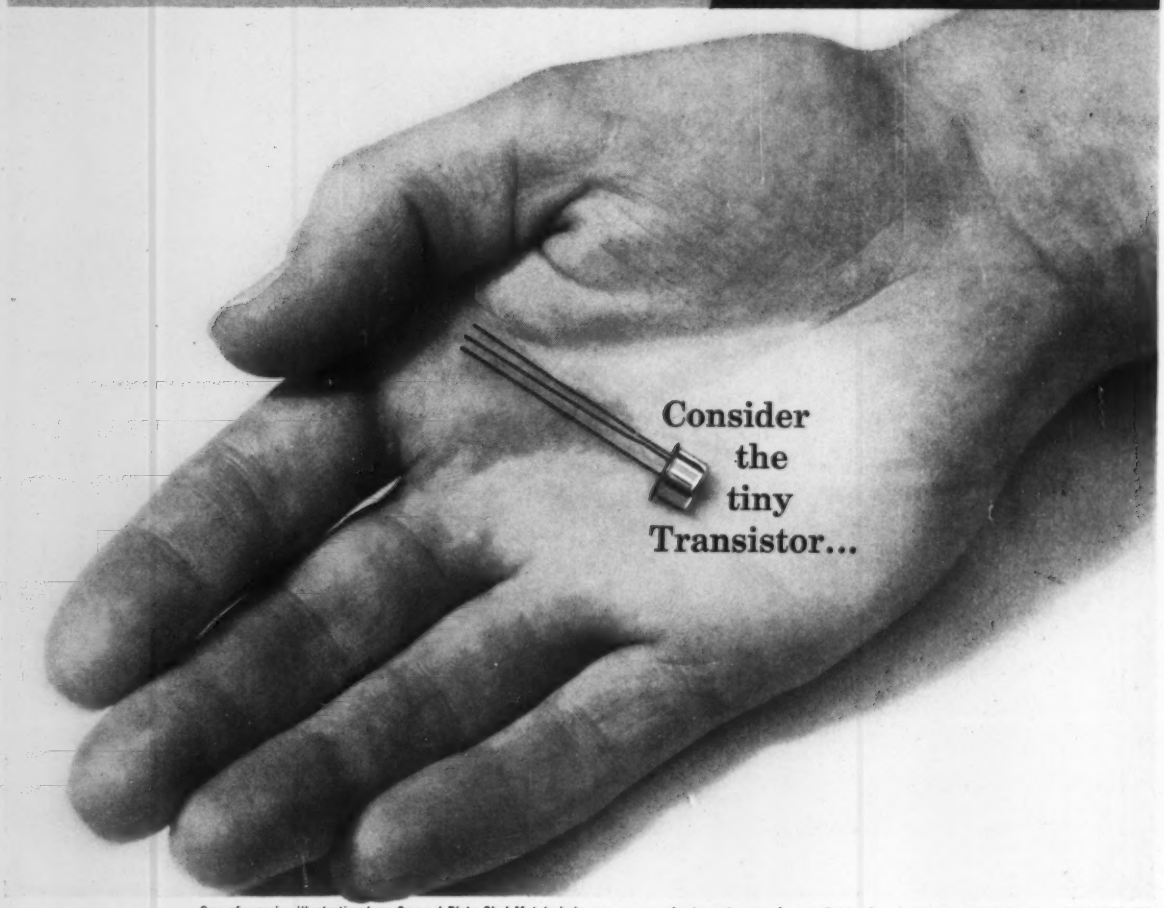

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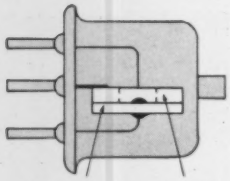

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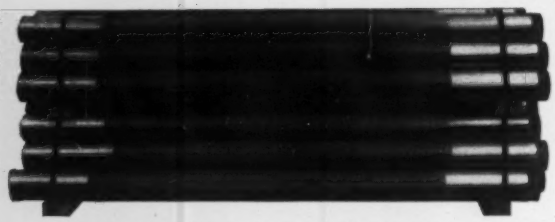

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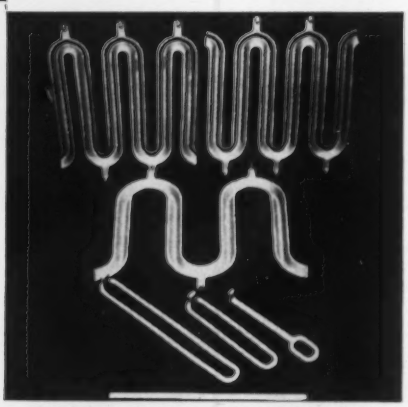

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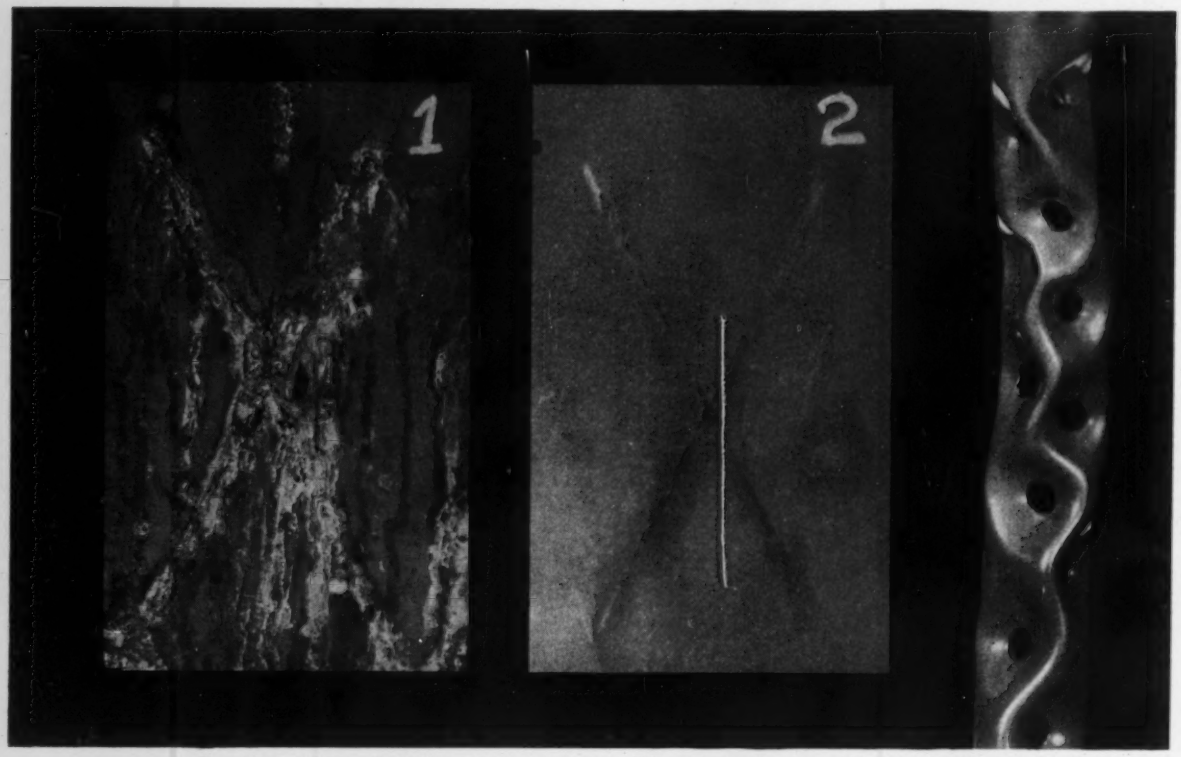

These two panels were identically painted, scored with an "X", and exposed to salt spray test for 480 hours. The difference: the one on the right was first treated with an Oakite CRYSCOAT iron phosphate conversion coating.

This painted tubing was CrysCoated. Repeated punching did not break paint grip despite severe abuse and deformation.

Oakite CRYSCOAT iron phosphate coatings cut the cost of corrosion-protection

You get proper protection *plus* economy with CrysCoat iron phosphate coatings.

First of all, they lock paint to steel, giving a superior paint grip under bending stresses. Bend tests show less chipping and flaking of paint. And note how paint held tight even at punched holes in the sample above.

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Unbreakable and Unbeatable—because it's made of PLIOFLEX!

Drop one of these flower pots, it bounces back for more. Use it for years, the bright color won't peel or change.

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Cotter pins	Push-Pull controls	Welding strip
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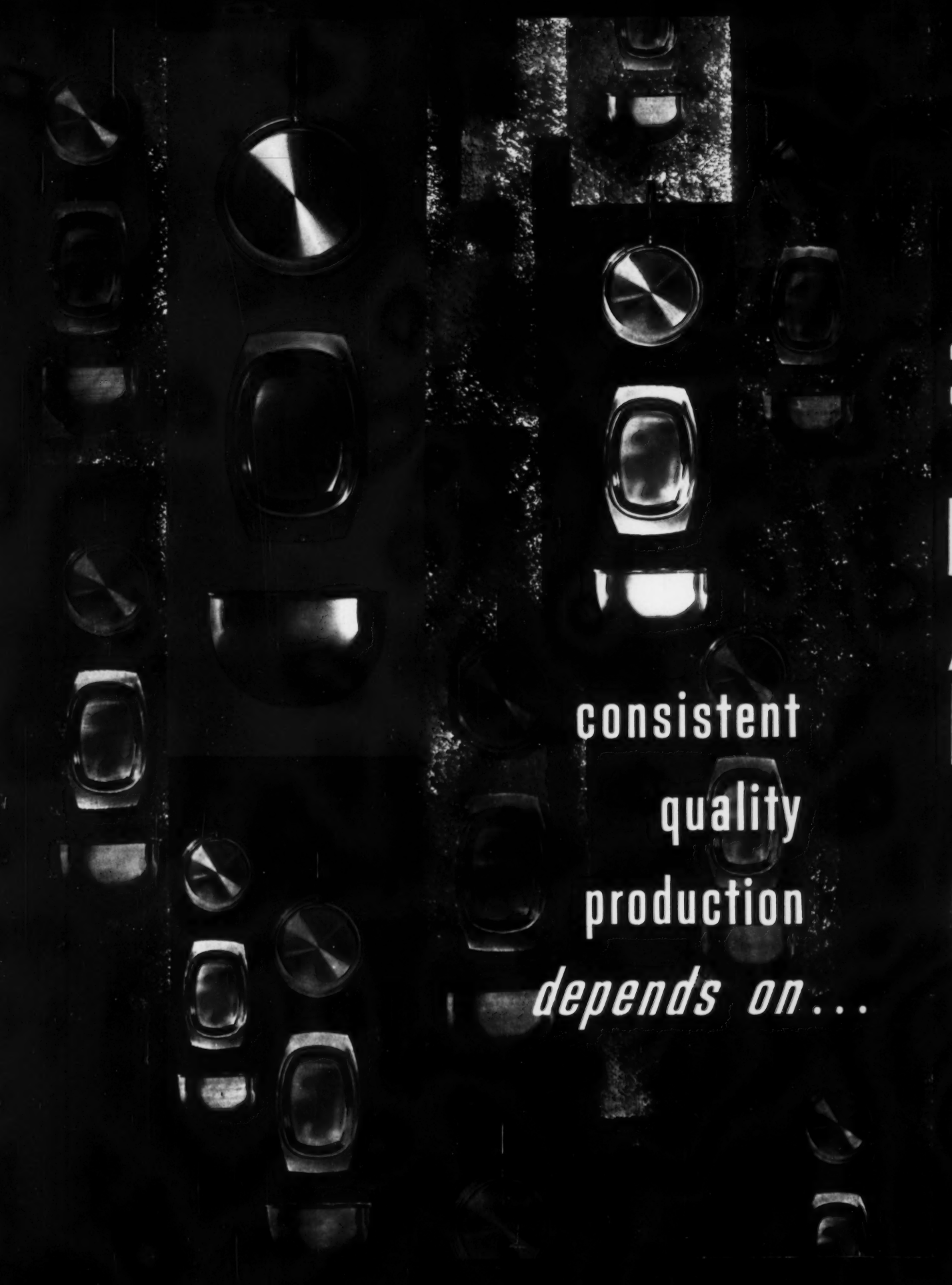
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consistent quality

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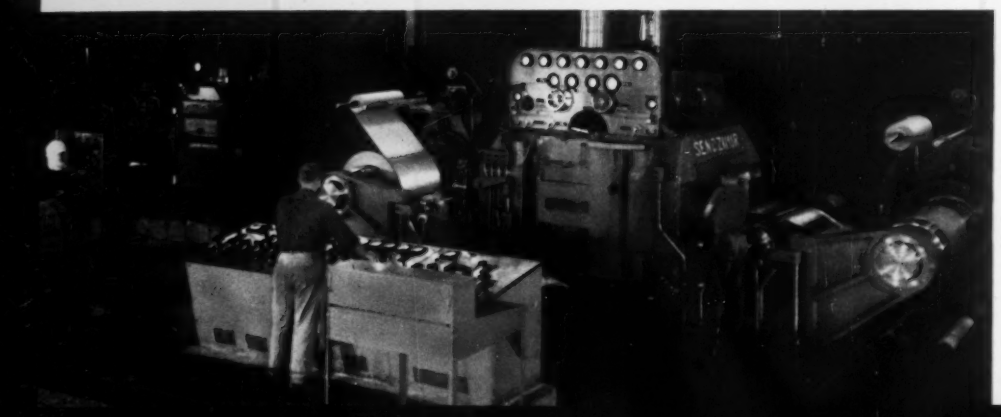

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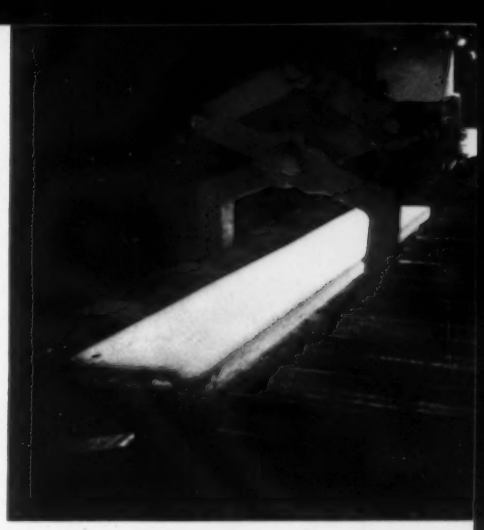
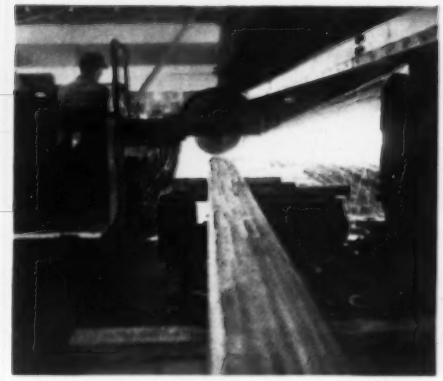
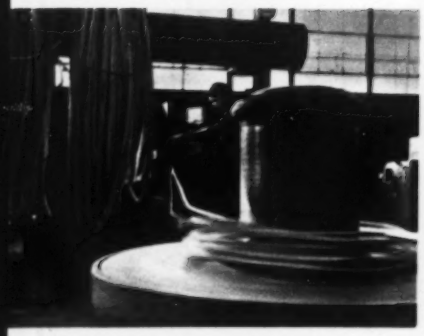


The quality of billets and slabs governs the quality of finished products.



Conditioning of slabs and billets to exacting standards assures flawless surface finishes.

stainless steel



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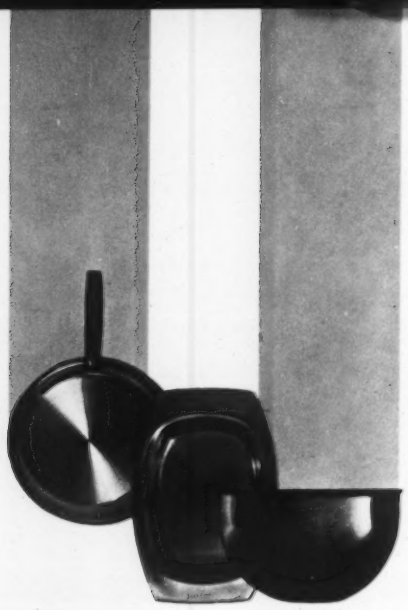

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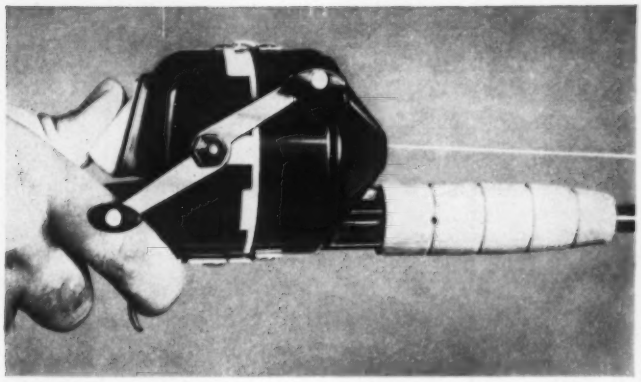
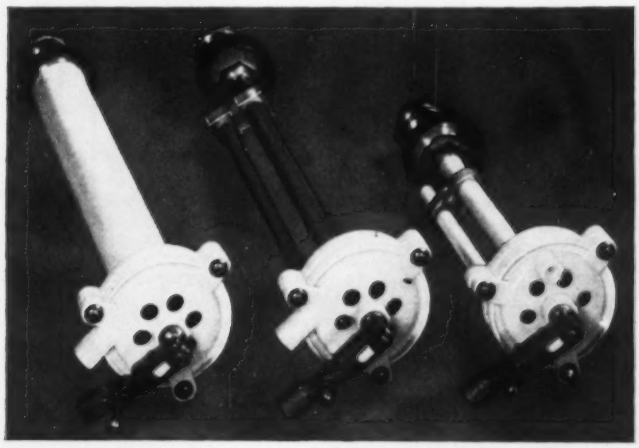
We will welcome the opportunity to assist you in evaluating how "Delrin" can help you improve a product, lower its costs or develop new designs for your profit.



The Zebco Company of Tulsa, Okla., cites "Delrin" as making possible a truly corrosion-proof salt-water spinning reel. In their "Fabulous Zebco 88", "Delrin" is used for the housing, thumb control and body. Zebco found in "Delrin" the stiffness, toughness, light weight, wear and corrosion resistance it needed. The "Fabulous Zebco 99" is also made of "Delrin" for long-lasting fresh-water spin fishing. (Molded by Continental Plastics Co., Oklahoma City, and Ajax Plastics, Tulsa, Okla.)

A new chain conveyor made by Union Chain & Manufacturing Co., Sandusky, O., features top plates molded of "Delrin". In switching from steel, the company states that "Delrin" offers constant dimensional stability, lower manufacturing costs and improved performance, because the smooth surface quality of "Delrin" means less spillage and breakage. (Molded by Anderson Associates, Toledo, Ohio.)

For their "Flow King" ball-cock valve (left in photo below), Coast Foundry & Manufacturing Co., La Verne, Calif., chose "Delrin" rather than brass for the valve's bonnets, because "Delrin" reduces production costs, and it has the required dimensional stability, stiffness and durability. These properties and savings (injection-molded "Delrin" eliminated all finishing operations) have prompted the use of "Delrin" for bonnets in two other valves. (Molded by Coast Craft Industries, Glendale, Calif.)



THIS IS WHAT DELRIN® IS DOING

During the past three years, over 500 applications of "Delrin" have been field-tested by some 250 manufacturing concerns. This development program measured the ability of "Delrin" to perform in actual service vs. counterparts made of metals, rubber, wood and glass. In each case, detailed cost studies were also made to measure the cost advantage of using "Delrin".

As a result, and with the recently announced commercial availability of "Delrin", over 100 applications are being put into commercial production: gears, bearings, housings, aerosol bottles, faucet parts, valves, sporting equipment, telephone components, households items and many others.

We suggest that you investigate how "Delrin" can be profitably used in the products you make and the products you use. Commercial processors and our own staff of technologists are ready to assist you.

POLYCHEMICALS DEPARTMENT

DU PONT

REG. U.S. PAT. OFF.

Better Things for Better Living . . . *through Chemistry*

FOR MORE SPECIFIC INFORMATION MAIL THIS COUPON

E. I. du Pont de Nemours & Co. (Inc.)
Department W-3, Rm. 2507D
Nemours Building, Wilmington 98, Delaware

I am interested in evaluating "Delrin" for the following use:

_____

NAME_____

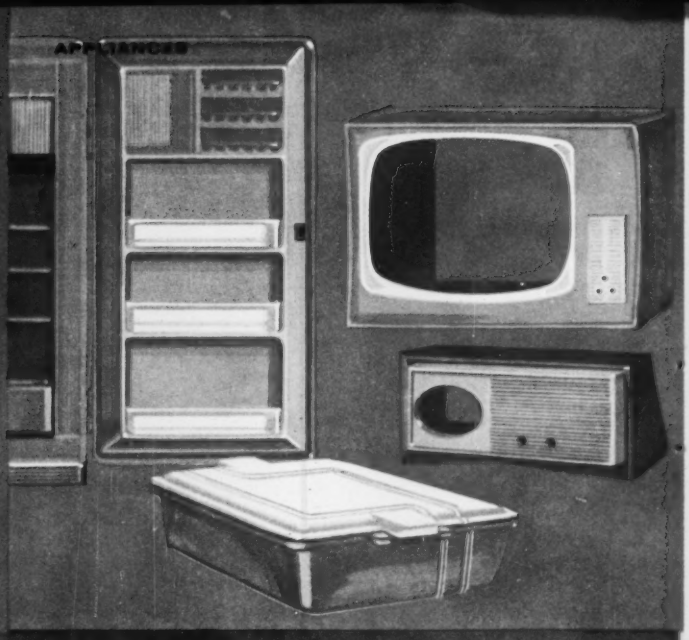
COMPANY_____ POSITION_____

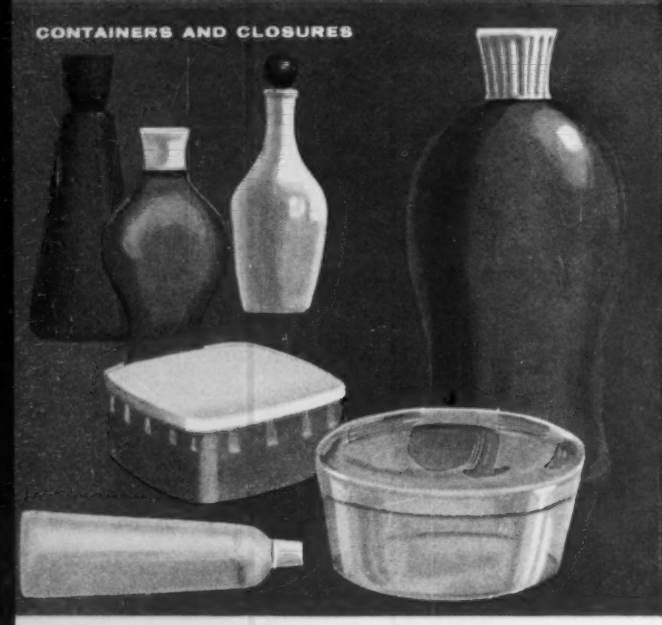
STREET_____

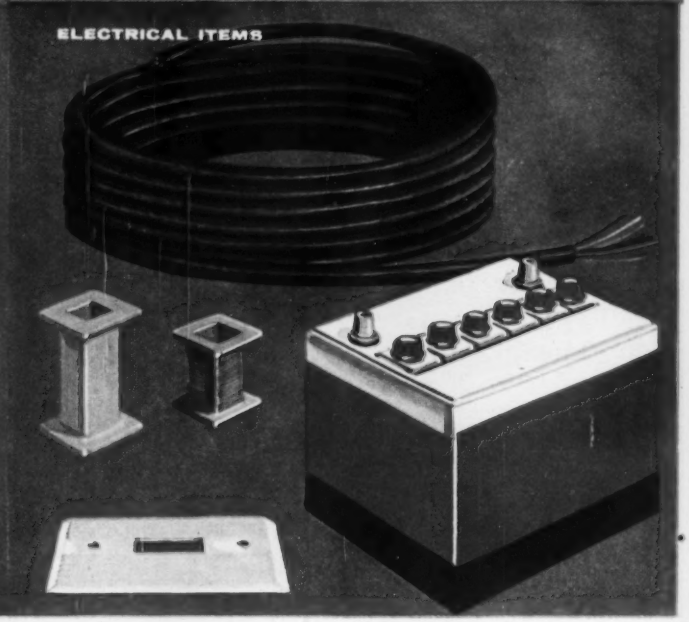
CITY_____ STATE_____

In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Que.

For more information, turn to Reader Service card, circle No. 488







This is only the beginning of the products you can make

better, easier, more economically

HOSPITAL AND LABORATORY WARE . . . beakers, hospital trays, bed pans, bottles and funnels. Products made from AviSun Polypropylene are lightweight—can be sterilized under hospital conditions—won't chip or crack—are quieter, cleaner. Products of AviSun Polypropylene also resist acids, alkalies, oils and salt solutions.

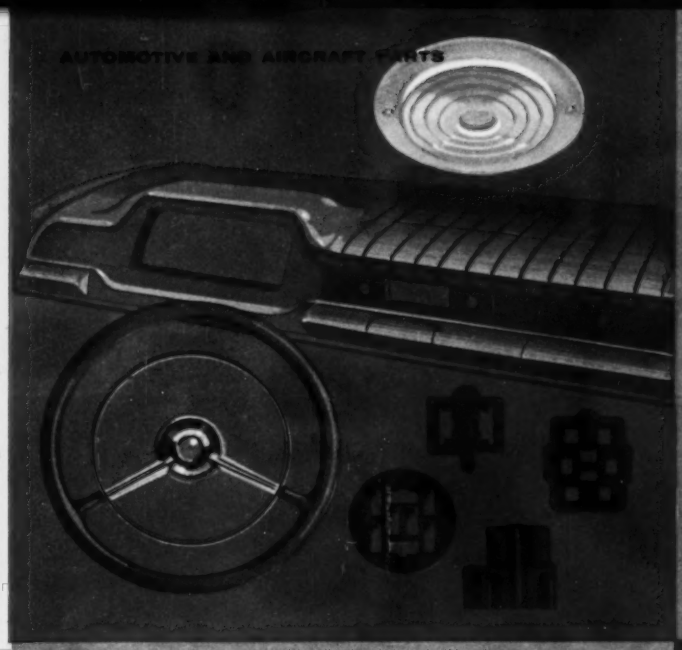
CONTAINERS AND CLOSURES . . . rigid bottles and closures for detergents, bleaches and chemicals—rigid containers of all shapes and sizes. Containers of AviSun Polypropylene are rigid, strong and highly resistant to cosmetics and essential oils. Closures have low creep and good resistance to cold flow. In addition, they do not stress crack and are considerably stronger than the other plastics they replace.

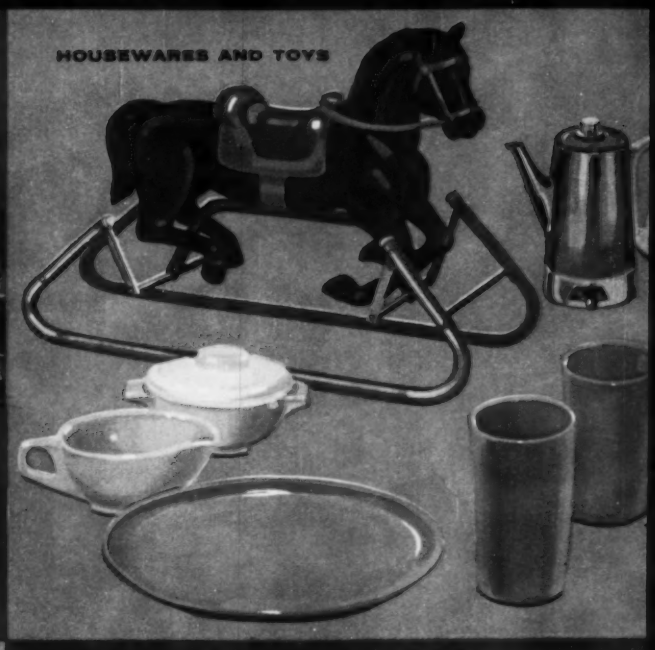
APPLIANCES . . . refrigerator door liners, freezer trays, TV and radio cabinets, TV yokes, intercoms, air conditioner grilles, and vacuum cleaner tools, bobbins, gears, rollers. Appliance components can be molded of AviSun Polypropylene at *remarkably low cost*. They're strong, rigid, highly heat resistant—have excellent dimensional stability and low cold flow.

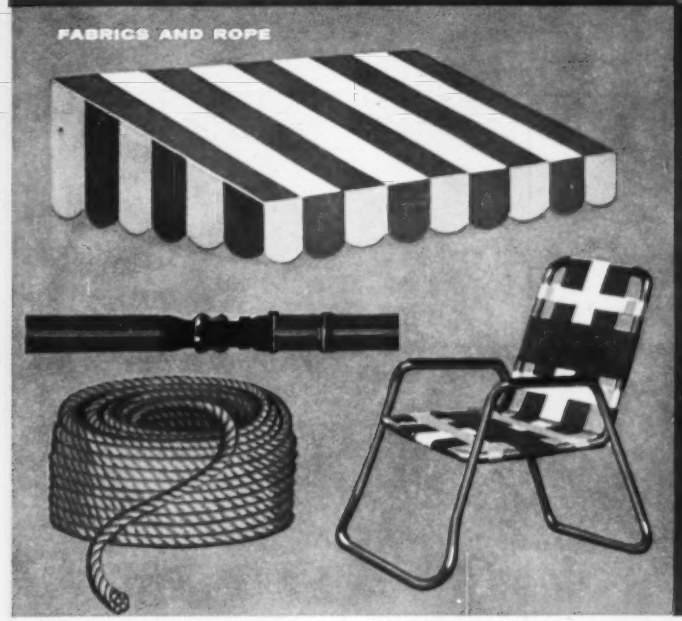
ELECTRICAL ITEMS . . . wire and cable insulation, as well as electrical components offer a good potential use for AviSun Polypropylene. It is a non-polar material with excellent dielectric properties, high volume resistivity and low moisture absorption. Also has remarkable heat resistance, abrasion resistance and weatherability. Battery cases, coil forms and insulators are suggested uses.

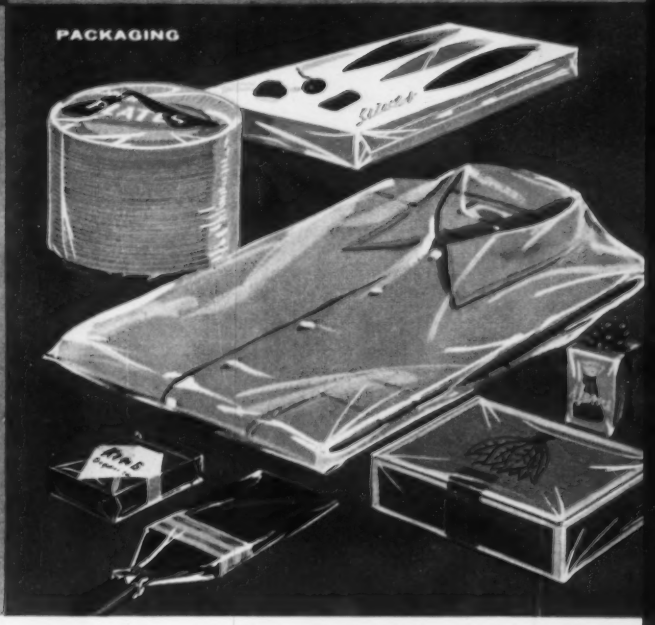
AUTOMOTIVE AND AIRCRAFT PARTS . . . dome lights, dashboards, control knobs, steering wheels, visors, windshield washer reservoirs and auto upholstery monofilaments. Great resistance to stress cracking and heat, plus toughness and rigidity make AviSun Polypropylene ideal for many automotive applications. Its light weight and *economy* add to its appeal in this field.

FABRICS AND ROPE . . . marine rope, bristles and industrial fabrics, automobile upholstery, awnings, furniture webbing and filters offer great promise as end products for monofilaments made from AviSun Polypropylene. It is lightweight (actually floats), is mildew proof, and has high tensile strength as well as outstanding wearability and resistance to chemicals and moisture.









For more information, circle No. 485

with AviSun Polypropylene

HOUSEWARES AND TOYS . . . coffeemaker parts, cups, saucers, dishes—both intricate and giant-size toys. AviSun Polypropylene is easy to injection and blow mold with fast cycles and low shrinkage. Ideal for stiff, thin-walled items. Can be molded in bright colors—resists oils, detergents, bleaches. No warpage, even in high-heat dishwashers.

PACKAGING . . . individual packaging, overwraps, sterilizable bags, vacuum-formed blister packages from heavy sheet. Film made from AviSun Polypropylene polymer is crystal clear, sparkling, with just the right rigidity. The sheet is stiff enough to use in thin gauges on automatic packaging machines. Both are highly heat, chemical, grease and oil resistant.

For the complete story of AviSun Polypropylene, MAIL COUPON FOR FREE 12-PAGE TECHNICAL DATA BOOK TODAY

*

AVISUN

*a trademark of AviSun Corp

AVISUN Corporation
309 Post Road, Marcus Hook, Pa.

Please send me your 12-page Technical Data Book covering AviSun Polypropylene resins.

NAME _____ POSITION _____
Please Print

COMPANY _____

ADDRESS _____

CITY _____ ZONE STATE _____

NICHOLSON
U.S.A.
NICHOLSON
U.S.A.

Good to the last bite . . .

Nicholson files and rasps, manufactured by the Nicholson File Company of Providence, Rhode Island, are regarded by tool experts as among the finest in the world. A long history of experience and research has taught Nicholson craftsmen how to make good, long-lasting products.

In file or rasp-making, preparation of the steel is paramount. After precision forming, the steel is carefully heat treated to develop uniform internal grain structure. A reciprocating chisel cuts the teeth, then the file or rasp is heated in a lead bath and quenched to develop hardness. It is cleaned and sharpened by sandblasting, the tang is heat treated to improve toughness, and the file is finally inspected.

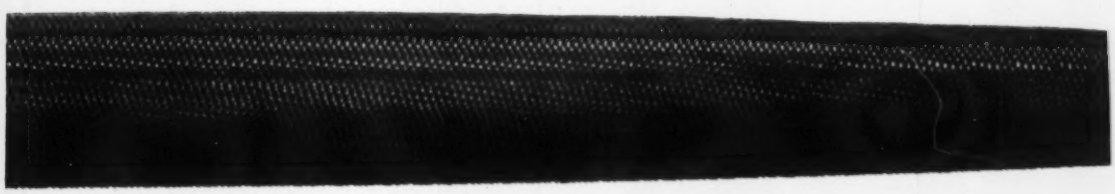
U.S.Steel metallurgists have worked closely with Nicholson's designers to provide just the right special-purpose steel for each special-purpose file or rasp. Just as there is no one all-purpose file or rasp, steels, too, are made with an almost countless variety of physical and chemical properties. Every day U.S. Steel produces "special purpose" steels, with a chemistry to meet a designer's specific requirements. As the Nicholson File Company knows, "steel" is not a single product. It is an almost limitless array of practical solutions to the problems of the most imaginative and demanding designer. U.S. Steel research is available at all times to help you get a job done right. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

USS

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

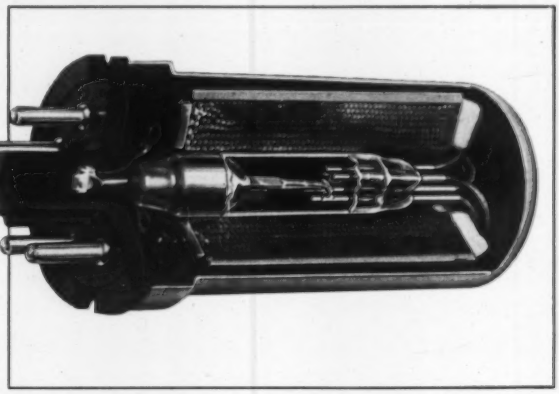


BISHOP Tubular Products NEWS

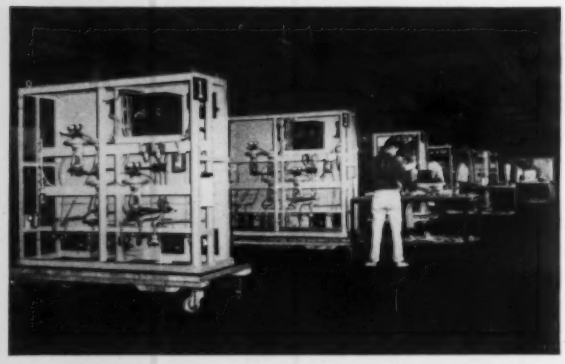
"METALS FOR PRECISION AND PERFORMANCE"

C. P. CLARE'S MERCURY-WETTED CONTACT RELAYS PERFECTLY SEALED WITH GLASS-TO-METAL SEALING ALLOY

C. P. Clare & Company, Chicago, Illinois, produces a complete line of mercury-wetted contact relays characterized by long life, high speed of operation and no contact bounce. To supply relays that have a conservative life expectancy of more than a *billion* operations requires absolute perfection in all phases of manufacturing. C. P. Clare uses BISHOP's #52 alloy tubing for the critical tubular stems of these relays. Mercury and hydrogen at 150 psig are introduced through this connecting stem—which is then sealed off by welding and forging. Can glass-to-metal sealing alloys solve any of your problems? BISHOP makes a complete line . . . use the coupon for details.



TUBING TAKES 5,400 PSI IN HONEYWELL'S MISSILE CHARGING SYSTEM



Super pressure stainless steel tubing connects many components of the cubicles illustrated. Minneapolis-Honeywell's Missile Equipment Division, Pottstown, Penna. builds these control cubicles that make up the gas charging system for the Bomarc missile. BISHOP supplies Honeywell with two sizes of 304 seamless super pressure tubing for this application. During charging of the missile, tubing handles pressures up to 5,400 psi. If you use small diameter tubing—super pressure, commercial quality or other—consider BISHOP. Use the coupon for a copy of BISHOP's Tubular Products Bulletin.

J. BISHOP & CO.

platinum works

FOR HELPFUL DATA USE THIS HANDY COUPON

- ☐ Glass-To-Metal Sealing Alloy Data
- ☐ Tubular Products Bulletin No. 12
- ☐ Special Tubing Data
- ☐ Platinum Products Catalog No. 4

Check information you'd like and mail to J. BISHOP & CO., 40 King St., Malvern, Penna.

Name

Position

Company

Address

City Zone State

Tubular Products Division

40 KING STREET, MALVERN, PENNA.

NIagara 4-3100

THIS IS THE BISHOP LINE:

Products of all the Platinum Metals... Small diameter Stainless Steel, nickel and special alloy tubing

For more information, turn to Reader Service card, circle No. 366

NEW DESIGNS IN MARLEX

Armour Chiffon gains new sales in containers made of MARLEX*

Today, the big news in packaging household products is the switch from metal and glass to containers made of rigid polyethylene. These new plastic containers are lighter and rust-proof . . . will not dent . . . and if dropped, will not break or chip dishes. Impermeable and chemical-resistant, the MARLEX 5000 Series Resin used in these detergent containers possesses such superior stress cracking resistance and strength per mil of wall thickness that it is also being evaluated for containers of such hard-to-hold products as disinfectants, bleaches, toiletries, waxes, cleaning agents, and the like.

Robert Sidney Dickens, the designer of this new 22-ounce container for Armour and Company, is enthusiastic about this MARLEX resin. "This plastic," he says, "permits a variety of shapes and forms not feasible in metal. The designer is free to create a more practical and aesthetic package. For example, we designed the new Chiffon container to suggest the mild and gentle qualities of this detergent. It is also shaped so as not to slip from suds-covered hands."

Mr. Dickens found MARLEX an exciting material to work with. And you . . . designing a new product? Need to reduce costs . . . improve a product? MARLEX Linear Polyethylene can be the answer. This high-quality plastic—used for countless items from toys to lawn mower casings—is rigid, tough, durable, colorful, lightweight . . . resistant to heat and cold, 250°F. to −180°F. It has excellent electrical properties . . . is unaffected by most acids, chemicals, oils, greases . . . cannot rust, rot or corrode. For full details, contact the nearest office below.

Designer . . . Mr. Robert Sidney Dickens, President of Dickens, Inc., Chicago, Ill.

*MARLEX is a trademark for Phillips family of olefin polymers

PHILLIPS CHEMICAL COMPANY, Bartlesville, Oklahoma, A subsidiary of Phillips Petroleum Company

PLASTICS DIVISION OFFICES

NEW ENGLAND	NEW YORK	AKRON	CHICAGO	WESTERN	SOUTHERN
322 Waterman Avenue	80 Broadway, Suite 4300	318 Water Street	111 S. York Street	317 N. Lake Ave.	6010 Sherry Lane
East Providence 14, R. I.	New York 5, N. Y.	Akron 8, Ohio	Elmhurst, Ill.	Pasadena, Calif.	Dallas 25, Texas
GEneva 4-7600	Digby 4-3480	FRanklin 6-4126	TErrace 4-6600	MUrray 1-6997	EMerson 8-1358

PHILLIPS 66 MARLEX

EXPORT: PHILLIPS PETROLEUM INTERNATIONAL CORPORATION • P. O. Box 7239, Panama City, Panama • Sumatrastrasse 27, Zurich 6, Switzerland

For more information, turn to Reader Service card, circle No. 445

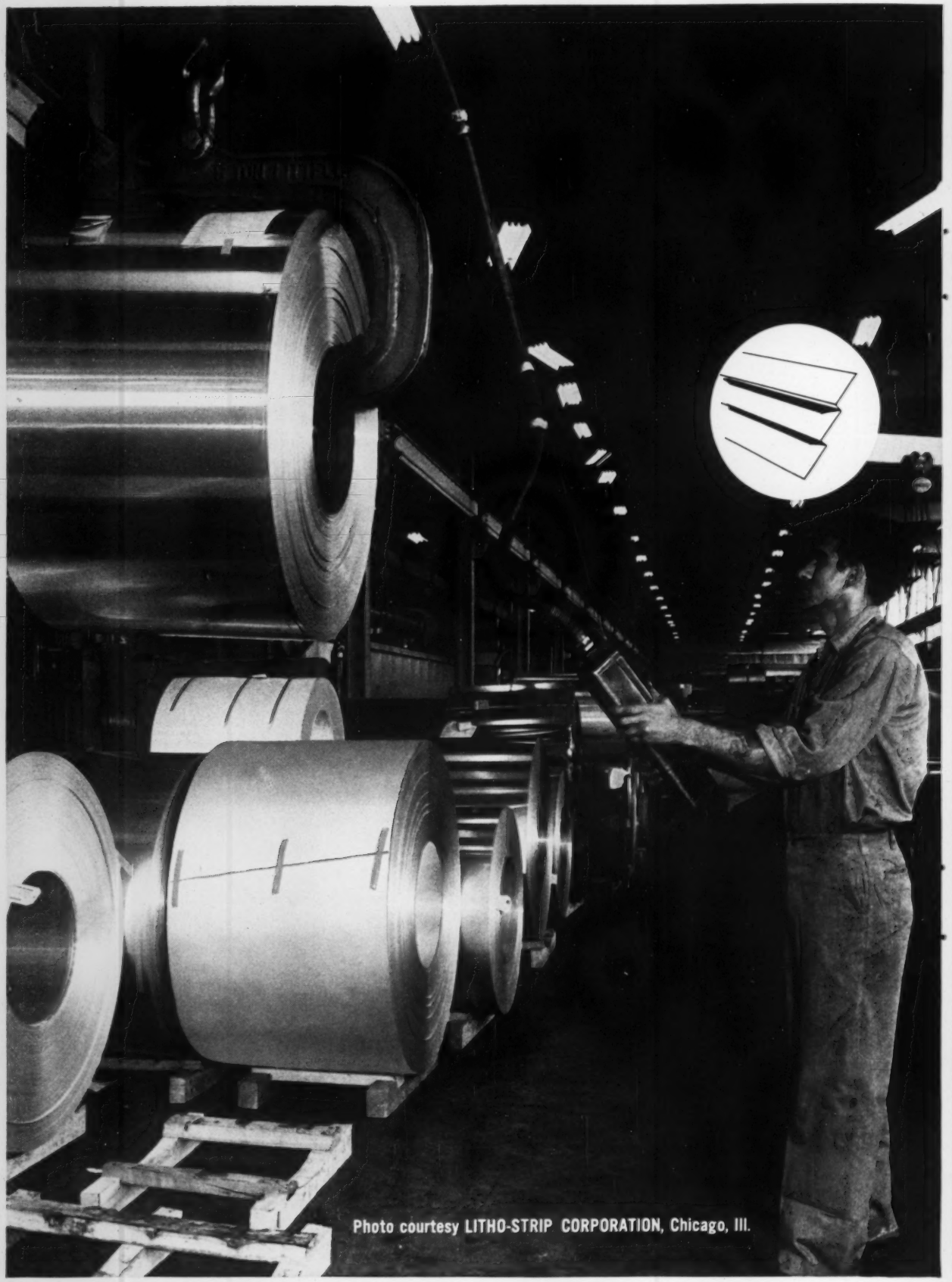
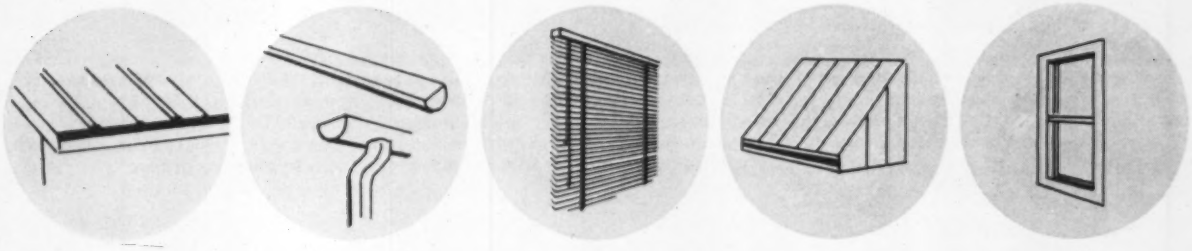


Photo courtesy LITHO-STRIP CORPORATION, Chicago, Ill.

BONDERIZED ALUMINUM

makes your painted products look better longer



Most famous of all surface treatments for metals—BONDERITE—makes painted aluminum look better longer.

Bonderite on aluminum means fine appearance longer, because it controls corrosion and anchors the paint.

Bonderized and painted aluminum is produced on automated strip lines in which the metal is cleaned, Bonderized and painted, then re-coiled ready for use.

Stamped or roll-formed products are made from pre-painted, Bonderized aluminum coil without loss of paint adhesion, even from the most severe deformation. Here's production efficiency and economy at its best—better products at less cost.

Many Applications of Bonderite for Aluminum

There's more than one type of Bonderite for use on aluminum. In wide use is Bonderite as a base for paint, which adds durability and long life to paint finishes on so many aluminum products.

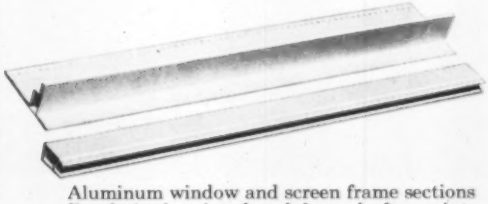
Another Bonderite produces an attractive green coating, used on many architectural products without further finish.

Protection without changing the characteristic color of the metal is provided by another Bonderite.

There is also a Bonderite, formulated for mixed production, which coats aluminum, steel and zinc.

Bonderite for aluminum meets and exceeds the requirements of Government Specification MIL-C-5541.

Well over two hundred plants—large, medium-sized and small—use these great Parker products on their aluminum production. Better investigate for *your* plant, today!



Aluminum window and screen frame sections Bonderized, painted and formed after painting. No breaks in finish anywhere! (Courtesy, Security Co., Detroit, Mich.)

SEND FOR ILLUSTRATED BULLETIN!—*Free bulletin, with more complete information and details, mailed immediately upon request. Ask for Bulletin A6790, "Bonderite for Aluminum."*

Parker Rust Proof Company

2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

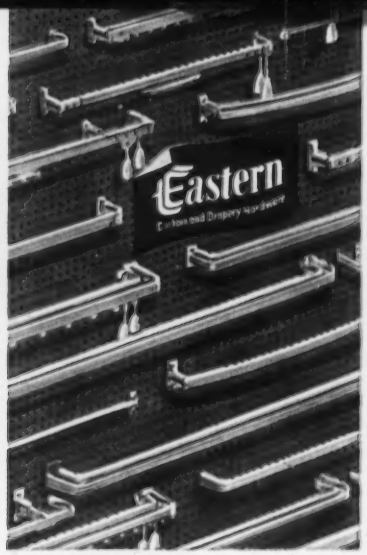
BONDERITE corrosion resistant paint base	BONDERITE and BONDERLUBE aids in cold forming of metals	PARCO COMPOUND rust resistant	PARCO LUBRITE—wear resistant for friction surfaces	TROPICAL—heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

For more information, turn to Reader Service card, circle No. 347

NEW EASTERN'S STAR VENETIAN BLINDS have unusual "S"-shaped slats that interlock on closing to prevent light show-through. "Dulux" in a wide variety of colors beautifies these modern blinds. At right are recently introduced *vertical* blinds.

SILENT CEILING, an all-metal acoustical ceiling by Eastern, can be quickly and easily installed because the panels lock together. Multi-coats of "Dulux" are used on the panel face, one coat on the back... baked on for permanence of bond.



EASTERN'S DRAPERY HARDWARE is finished with special "forming" types of "Dulux" applied to the metal *before* fabrication... does not chip, peel or crack during punching or bending.

Du Pont DULUX® Enamel adds finishing

SALES APPEAL BY THE CARLOAD. Du Pont ships "Dulux" Enamel to Eastern in specially designed tank cars, each divided into three compartments to accommodate the various formulations needed. Harry S. Rosenbaum, Eastern's president, Charles H. Rosenbaum, vice president, A. F. Walzinger, sales manager, and Julius Satowsky, assistant to the president (left to right above), are particularly enthusiastic about the convenience and efficiency of such bulk shipments.

Du Pont Finishes Service Package—**FORMULATION, APPLICATION,**

AIRLUME* ROLL-UP ALUMINUM AWNINGS are rustproof and keep a fresh appearance for season after season. Their sparkling "Dulux" finish starts bright . . . *stays* bright . . . withstands sunlight, weathering and temperature extremes. These awnings roll up snugly, require no prewinding.

EASTERNWEAVE* ROLL-UP SHADES AND FOLDING DOORS are made of aluminum "reeds" woven with thread of "Dacron"* polyester fiber. "Easternweave" is durable, complements any room in decorator colors of "Dulux". Above William Leizman, assistant to the president, and Frank Burrell, comptroller, examine a sample.

sales touch to EASTERN Products . . .

- Versatile "Dulux" keeps pace with rapid growth and wide diversification of Eastern Products Corp.
- Meets highly specialized finishing requirements in wide range of application techniques
- Du Pont's help in developing this finishes program is typical of the cooperation you can expect

In 25 years, the Eastern Products Corp., of Baltimore, Md., has grown from a pioneer manufacturer of metal venetian blinds to a giant in the home furnishings field. Du Pont has worked with this firm from the start in developing efficient finishing programs to give each product line the eye-catching beauty of "Dulux" Enamel.

As Eastern diversified, every type of application technique for "Dulux" came into play . . . flow coating, dipping, roller coating and spraying. Du Pont specialists helped Eastern's skilled personnel set up and perfect each stage of the finishing process. Today, Du Pont service continues—assuring consistently smooth operation.

Like Eastern, most manufacturers can benefit when experienced Du Pont personnel work with them to assure efficient use of industrial finishes. Here is experience *in depth* . . . from technically trained Du Pont service men and the field service laboratories of the world's foremost paint-research organization.

Du Pont specialists have the background needed to apply finishes by any method, in practically any industry. They'll recommend a finishes system that can solve your particular problem . . . work with your personnel on a continuing basis. Best of all, *they can help you develop better finishing at lower costs!*

If finishing is a key part of *your* production, it will pay you to see a Du Pont representative. Call or write: E. I. du Pont de Nemours & Co. (Inc.), 2502 Nemours Bldg., Wilmington 98, Delaware.

REGULAR INSPECTIONS keep efficiency high on the finishing lines. Here (left to right) Herman Steingass, Eastern's chief engineer, and Charles W. Pulfrey, Du Pont regional technical supervisor, discuss the finish on venetian blind slats with E. W. Young, Du Pont salesman, and John S. Walsh, Eastern's chief chemist.

*Reg. U. S. Pat. Off.

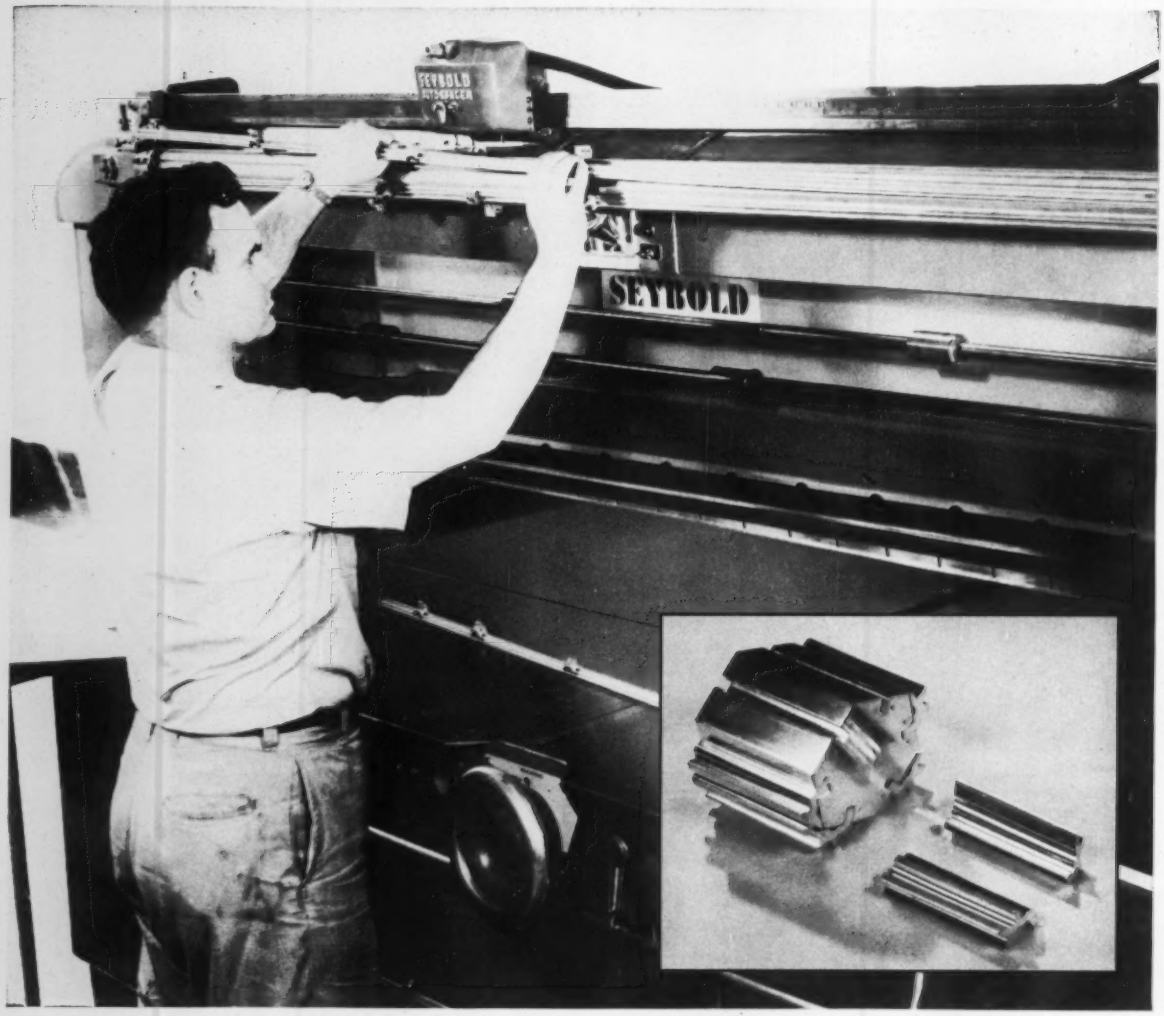
FOLLOW-THROUGH—*Sets Today's Production Pace*

DU PONT
REG. U.S. PAT. OFF.

For more information, turn to Reader Service card, circle No. 320

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

DOW | *Now in magnesium and aluminum*



PRECISION MAGNESIUM EXTRUSIONS (inset) form two key parts for hydraulic paper cutter.

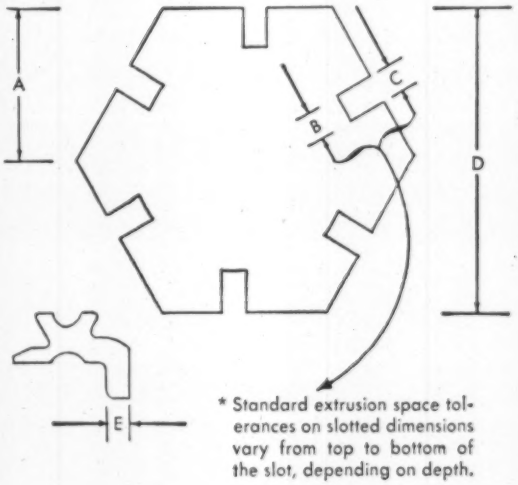
PRECISION EXTRUSIONS

tighten tolerances, cut costs

Paper cutter manufacturer slices production costs by replacing all-milled components with magnesium precision extrusions boasting tolerances as close as ± 0.0025.

Precision magnesium extrusions—a recent development of Dow's Madison, Illinois plant, deliver a big assist in the design of parts that must be extremely accurate and dimensionally stable. A wide variety of precision parts can be extruded with substantial savings in scrap loss, machining and setup time.

Harris-Seybold Company, a division of Harris Intertype Corporation, puts these advantages to work in the manufacture of hydraulic paper cutting machines. Results: six different machining and allied operations eliminated . . . machining and setup time for two key parts reduced by 64% and



* Standard extrusion space tolerances on slotted dimensions vary from top to bottom of the slot, depending on depth.

TOLERANCES HELD ON PRECISION MAGNESIUM EXTRUSIONS

Critical Dimension	Standard Extrusion Tolerance	Precision Extrusion Tolerance
A	± 0.012	± 0.0025
B*	± 0.007	+ 0.003 − 0.000
C*	± 0.012	+ 0.003 − 0.000
D	± 0.024	± 0.005
E	± 0.007	+ 0.000 − 0.003

78%. Basic material costs were also lowered. The metal previously used was supplied in a high-property alloy in order to minimize warpage during the extensive machining operations. The standard magnesium alloy now used costs less. In addition, straightening operations required with the previous metal are no longer necessary.

The two parts Harris-Seybold now buys as precision magnesium extrusions serve to position the paper correctly for a number of successive cuts. They range from 46 to 106 inches in length and must be both dimensionally accurate and free of kinks and bows. No machining of these extruded parts is required after they are received in the Harris-Seybold plant.

For facts and figures about precision magnesium extrusions as they apply to your requirements, write to THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Sales Dept. 1050CD3.

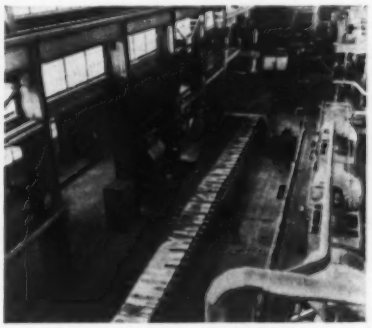
HOW MAGNESIUM PRECISION EXTRUSIONS CUT SETUP AND MACHINING TIME

PART AND MATERIAL	OPERATIONS REQUIRED	TOTAL SETUP & MACHINING TIME
Spacer Bar:		*10 pieces per production run*
Previous Metal	8	1,750 minutes
Magnesium Precision Extrusion	5	626 minutes
Stop Carrier Strip:		*60 pieces per production run*
Previous Metal	8	2,399 minutes
Magnesium Precision Extrusion	5	510 minutes

OPERATIONS ELIMINATED BY MAGNESIUM PRECISION EXTRUSIONS

Spacer Bar	Stop Carrier Strip
1. Straightening	1. Straightening
2. Milling slots	2. Milling critical dimension
3. Burring slots	3. Straightening

GIANT EXTRUSION PRESS, used to extrude magnesium and aluminum, produces sections up to 30-inch circumscribed circle. This 13,200 ton press extrudes large structural shapes of magnesium and aluminum for aircraft and missile parts, other applications.



ROLLING MILL at Madison, Illinois is the largest in the world for magnesium alloys. Flat sheet and plate and coiled sheet are produced in a wide range of sizes. Extra flat tooling plate for all tooling uses is also produced at this plant.

THE DOW METAL PRODUCTS COMPANY, Midland, Michigan

A Division of The Dow Chemical Company

For more information, turn to Reader Service card, circle No. 376

from dishwasher tops...to barge skegs...

GAMBLE solves problems with WOOD!

PROBLEM: Wood cutting-board tops of automatic dishwashers were splintering—and even distorting the machines themselves—from tangential swelling and shrinking of the tops.

SOLUTION: Gamble wood engineers developed a strip-constructed board, with edge grain exposed, which is now in volume use.

PROBLEM: The solid wood skegs (outer keel) of assault barges were cracking and splitting on beach landings.

SOLUTION: The *first* laminated skeg was researched and developed—then built in quantity—by Gamble Brothers.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

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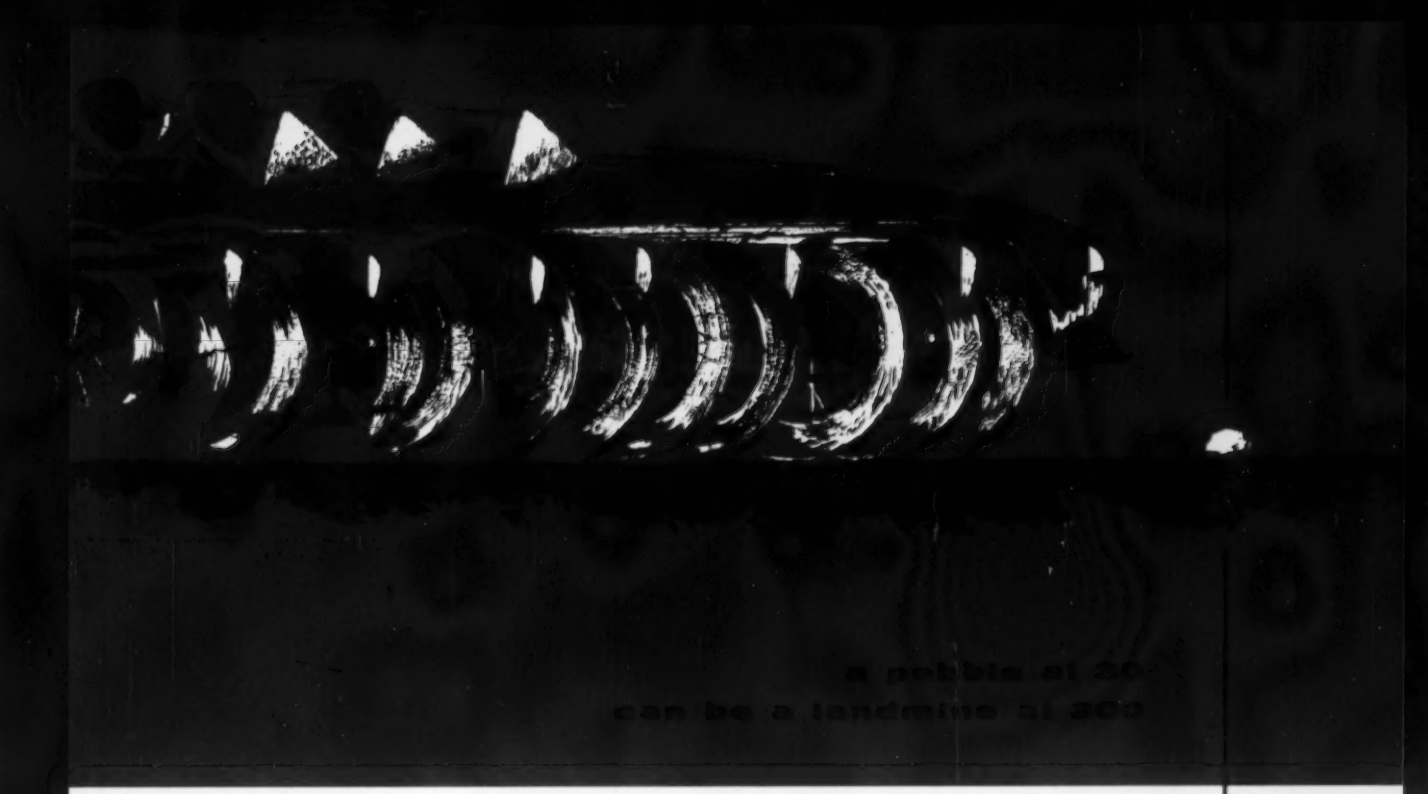
For more information, circle No. 453



a pebble at 30
can be a landmine at 200

the harder you drive for
super speed production
the more you need safe-
guards offered you in...

brass

copper

aluminum

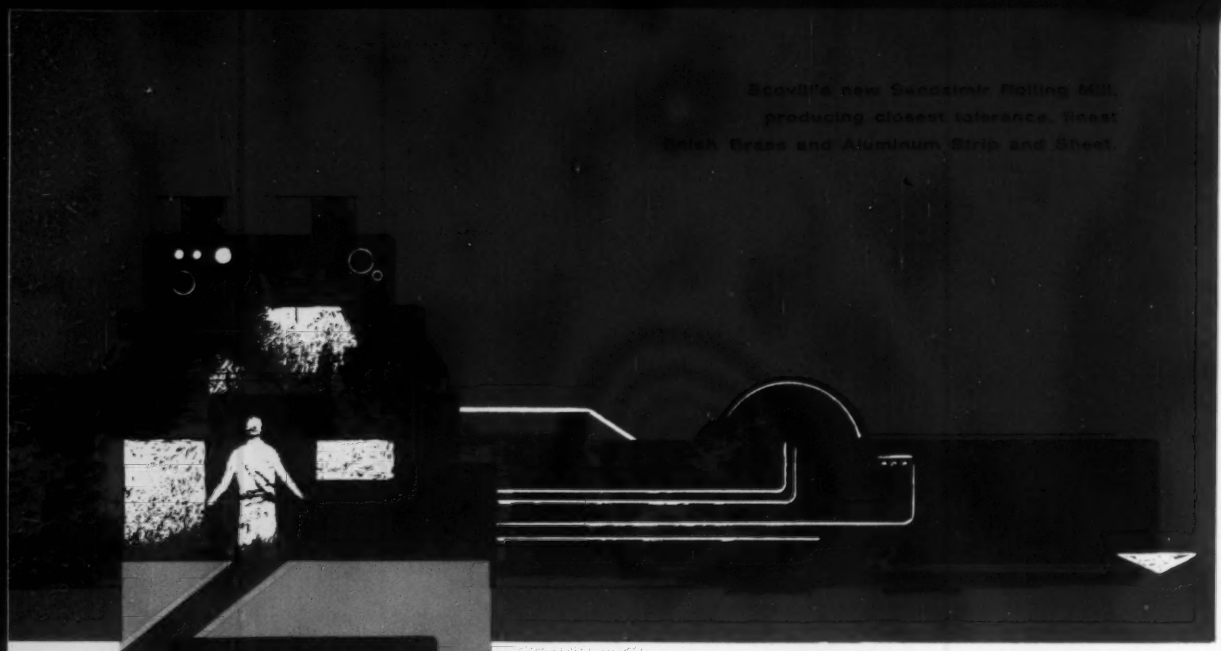
MILL PRODUCTS

MADE IN USA

. . . and made better to bring out the ***BEST*** *in your products*

Scovill Manufacturing Company, Mill Products Division, 99 Mill St., Waterbury 20, Conn. Phone PLaza 4-1171

3SC60



features
to help you take
full advantage
of today's
high speed
methods and
machines

Metal soundness and uniformity — For more than 20 years, unique Scovill *continuous casting* machines have been supplying a major part of the cast brass bars and billets used to produce strip, sheet, rod, wire and tube . . . over two billion pounds of metal that is inherently sounder and more uniform in every respect. This means fast running capability, minimum down-time and rejects, better quality products.

Close-tolerance specifications — Modern high-speed fabricating equipment is increasingly intolerant of what once were considered minor variations in grain size, temper, dimensions, surface finish. Scovill advanced engineering and quality-control procedures, working with new close-tolerance production equipment, meet or exceed the demands of highest-speed fabrication.

Selection of the right alloys — Scovill Metals Research maintains a continuing program of research into the practical needs of mill products fabricators. Scovill's broad range of alloys permits recommendation of exactly the right properties and qualities for a given job.

The industry's most advanced packaging — Packaging of Scovill Brass, Copper and Aluminum Mill Products can make a specific contribution to speed and efficiency in your operations . . . save you handling time and space in storage . . . cut production down-time and start-up. Scovill innovations include extra-long-run coils; Fast-Feed wire packages; easy-to-handle bundling or boxing of rod and tube.

Any fabricator who has made Scovill a part of his competitive team knows that these are only a few examples of the down-to-earth help and service he can depend upon. Call in Scovill NOW . . . especially if you want to get ideas and help in selection of the BEST metal for an important new product.

SCOVILL MANUFACTURING COMPANY
Mill Products Division, 99 Mill St., Waterbury 20, Conn., Phone Plaza 4-1171

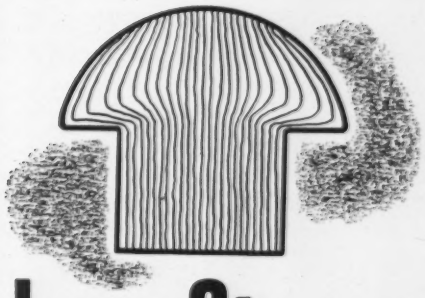
MILL PRODUCTS

MADE IN USA

. . . and made better to bring out the **BEST** *in your products*

4SC60

Five big reasons why cold-heading benefits you



1. LOWERS STEEL COSTS

The cold-heading wire itself is usually more economical than screw machine stock. Savings are often 10 per cent or more.

2. RAISES PRODUCTION RATE

Cold-heading is a high-speed process. You can adapt it to mass production techniques, increasing the production rates. Substantially lower costs are possible on large orders.

3. CUTS SCRAP LOSS

Scrap loss is reduced to a minimum because virtually the entire blank is used in forming the finished part.

4. INCREASES STRENGTH

The forging effect of cold-heading increases the strength of the part because it produces a favorable grain-fiber positioning. Lines of strength follow the part contours. Tiny, well-rounded corner fillets, resulting from cold-heading, also add to the part's strength.

5. REDUCES FINISHING OPERATIONS

The surface finish of a cold-formed part is usually excellent, and seldom calls for further processing.

Bethlehem manufactures a broad line of cold-heading wires to meet the requirements of practically every end use. Call the Bethlehem sales office nearest you for full details. Or write us at the address below.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Schlieren photograph showing heated air rising from Malleable chain link at 1200° F.

For Hot Parts... Use Malleable

Heat them up, cool them off—ten thousand times. Heat them up, keep them hot—indefinitely . . . you'll find you can count on Malleable iron castings for an exceptional combination of safety and economy.

New research demonstrates that the rugged room-temperature characteristics of Malleable castings remain virtually unchanged up to 800° F! More important—from 800° F. to 1,200° F., Malleable castings are unique in providing safe, dependable service **without** sudden drop in strength.

Let a nearby Malleable castings producer help you develop better, more economical parts for elevated temperature applications. Send drawings or an outline of your requirements to any of the progressive companies that display this symbol—

MEMBER

MALLEABLE CASTINGS COUNCIL

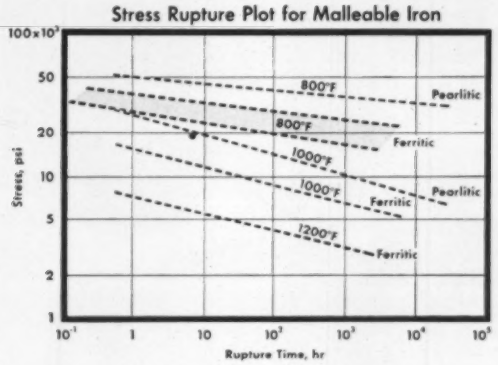
For detailed information on "Use of Malleable Castings in Elevated Temperature Applications," contact any company listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

Get Dependable Strength At Elevated Temperatures With Tough, Economical Malleable Castings

Malleable iron castings give you excellent service under rugged conditions at temperatures up to 800F. Even at temperatures as high as 1200F, at reduced stress levels, Malleable castings offer uniformly predictable properties.

Compare these stress-rupture curves for Malleable iron with other ferrous metals. Malleable's are straight, gradually declining curves . . . not curves that break sharply and suddenly downward. With Malleable you can count on long life.

Stress Rupture Plot for Malleable Iron



At temperatures from sub-zero to over 800F, Malleable delivers more strength per dollar than any other metal, ferrous or non-ferrous. In addition, your products will profit from Malleable's exceptional machining ease and uniformity, and the efficiency of the casting process.

Eight years of service at 900F without a failure! That's the history of these pearlitic Malleable conveyor chains carrying aluminum billets through a furnace. Similar Malleable chains have been subjected to temperatures as high as 1300F in sheet steel normalizing furnaces for years without failure.

Subjected to dynamic stresses at temperatures from 500 to 750F, these pearlitic Malleable truck and bus diesel engine pistons commonly provide more than 40,000 hours of service . . . over 1,000,000 miles!

Free Engineering Aid — To help you more exactly evaluate the possibilities of producing better products at lower cost with Malleable castings, send for *Data Unit 108—Elevated Temperature Characteristics of Malleable Iron Castings*. Your copy is available from any foundry listed below, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

For Quality and Economy... Use MALLEABLE

For Service In Your Area Contact...

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division
Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

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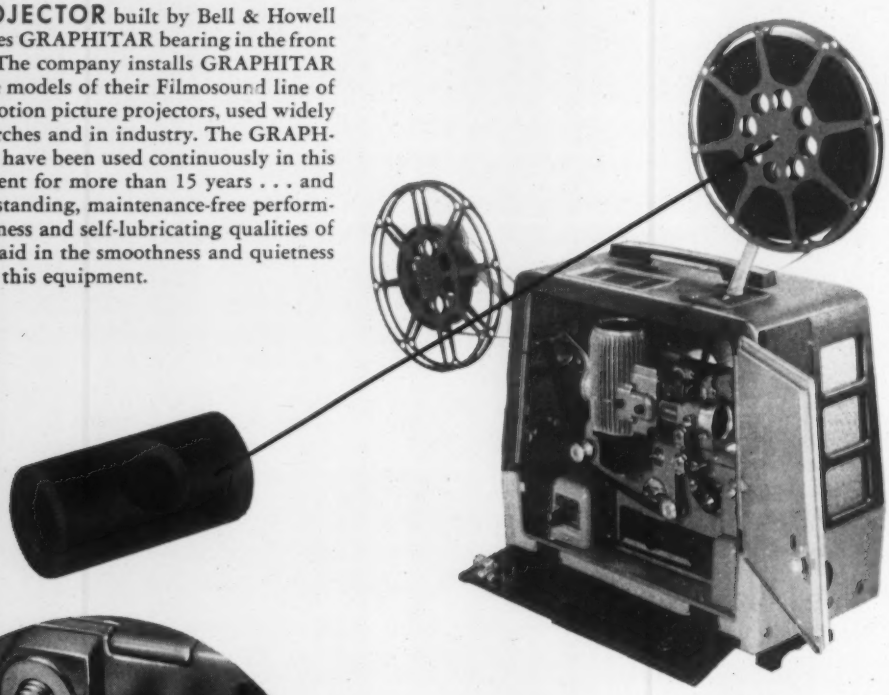
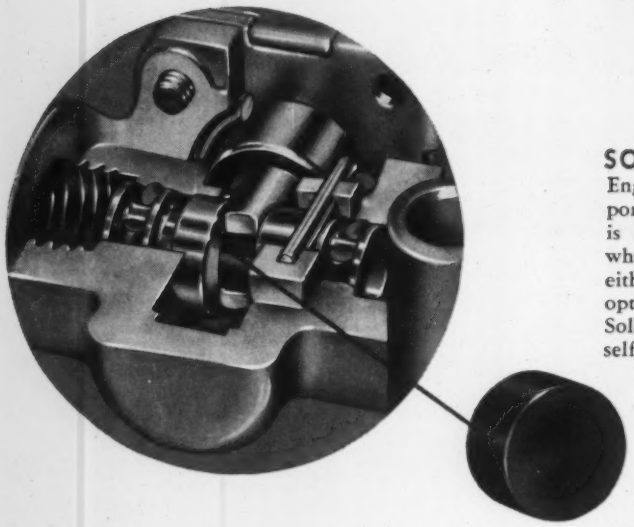
this is GRAPHITAR®

(CARBON-GRAPHITE)

successful in a wide variety of applications

MOVIE PROJECTOR built by Bell & Howell Company utilizes GRAPHITAR bearing in the front reel assembly. The company installs GRAPHITAR bearings in five models of their Filmosound line of 16mm sound motion picture projectors, used widely in schools, churches and in industry. The GRAPHITAR bearings have been used continuously in this line of equipment for more than 15 years . . . and have given outstanding, maintenance-free performance. The hardness and self-lubricating qualities of GRAPHITAR aid in the smoothness and quietness of operation in this equipment.

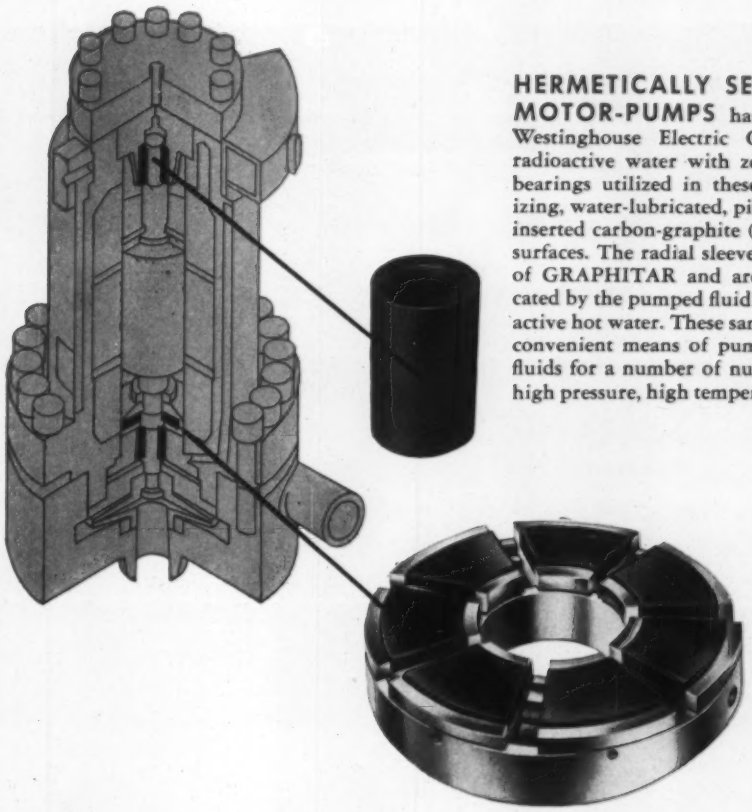




SOLENOID VALVES manufactured by Valcor Engineering Co. for use in guided missiles incorporate a floating seal of GRAPHITAR. This seal is a precise, optically flat GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. Solenoid valve improves with use due to unique self-lapping action of GRAPHITAR.

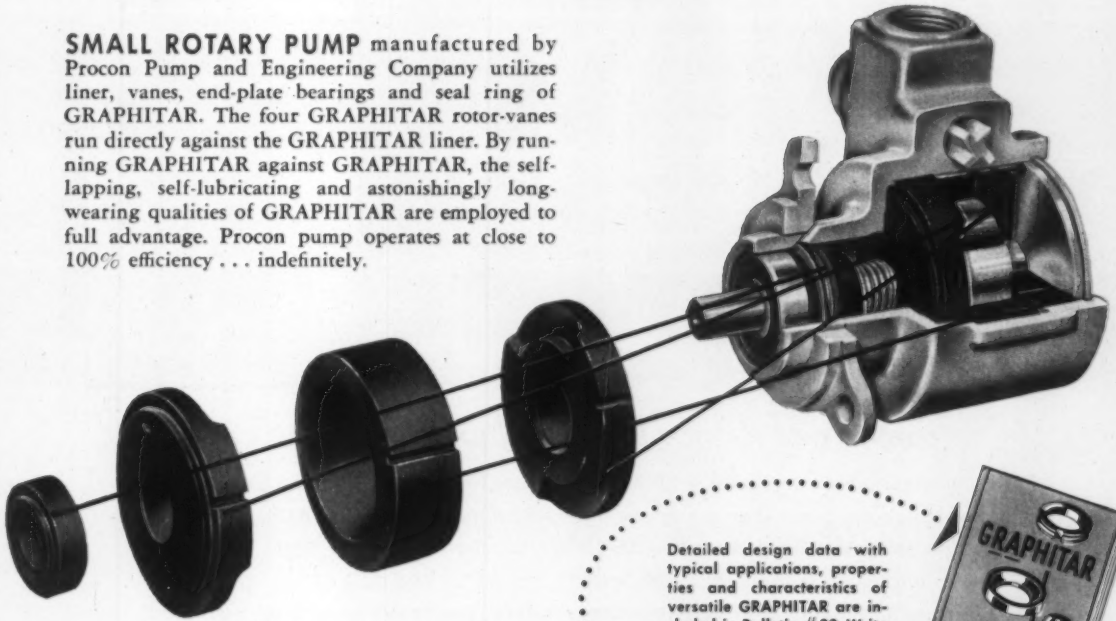
THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



HERMETICALLY SEALED MOTOR-PUMPS have been developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. The thrust bearings utilized in these pumps are self-equalizing, water-lubricated, pivoted-pad bearings with inserted carbon-graphite (GRAPHITAR) bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only, in this case, radioactive hot water. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

SMALL ROTARY PUMP manufactured by Procon Pump and Engineering Company utilizes liner, vanes, end-plate bearings and seal ring of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against the GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR, the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage. Procon pump operates at close to 100% efficiency . . . indefinitely.



Detailed design data with typical applications, properties and characteristics of versatile GRAPHITAR are included in Bulletin #20. Write for your free copy.

R-265-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

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CYCOLAC®

THE BORG-WARNER PLASTIC THAT'S TOUGH, HARD, AND RIGID

For their remarkable new Floor Washer the Hoover Company designed a total of 31 plastic parts, and specified that 15 key components be made of CYCOLAC. Hoover is using this Borg-Warner ABS plastic because it is tough, hard, rigid—**and** economical. It scoffs at scuffs, stains, hot water, and detergents—takes the roughest handling—helps keep the new floor washer virtually trouble-free. Being light in weight, CYCOLAC helps make the washer easy to use, too.

Plan now to test CYCOLAC yourself. Better in more ways than any other plastic.

GET THE FACTS
MARBON CHEMICAL
WASHINGTON

MARBON CHEMICAL BW BORG-WARNER

WRITE TODAY!
DIVISION **BORG-WARNER**
WEST VIRGINIA

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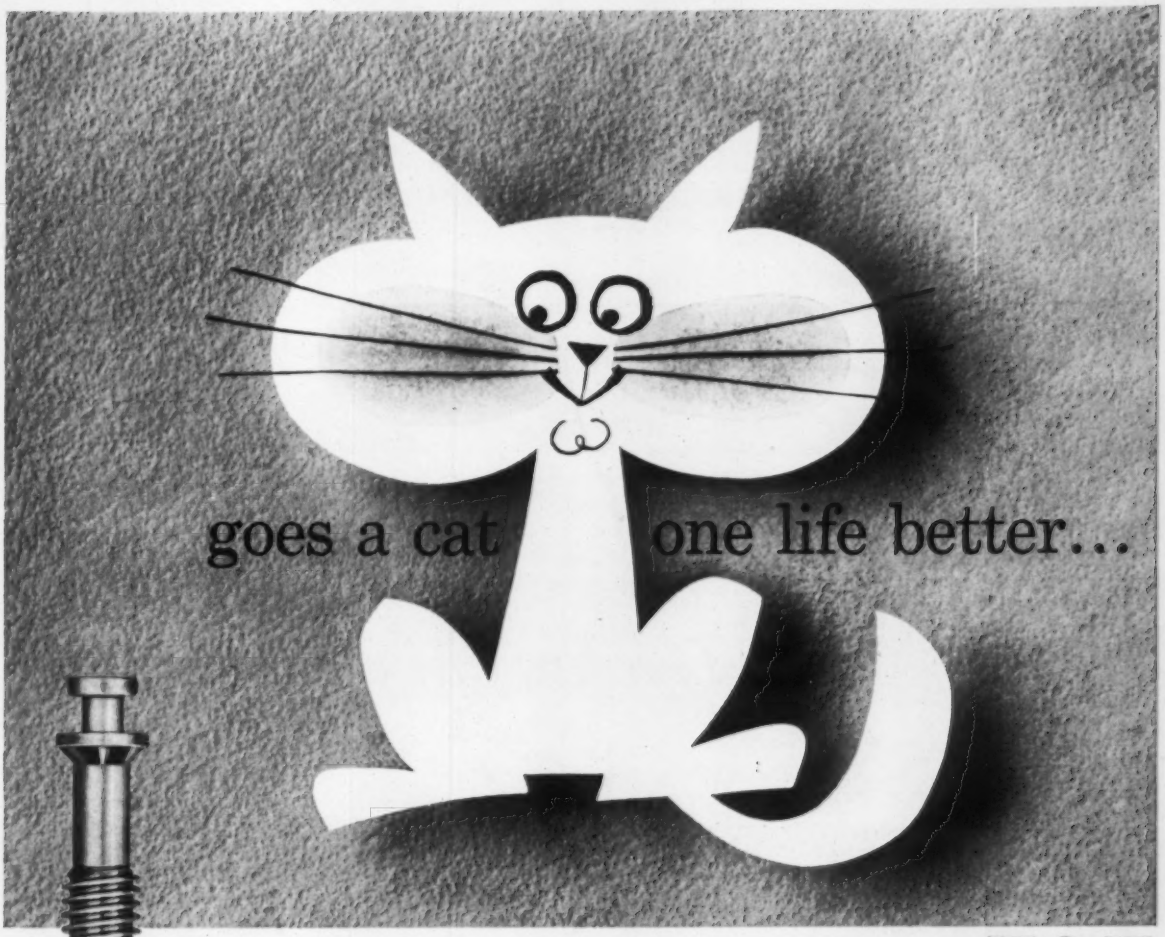
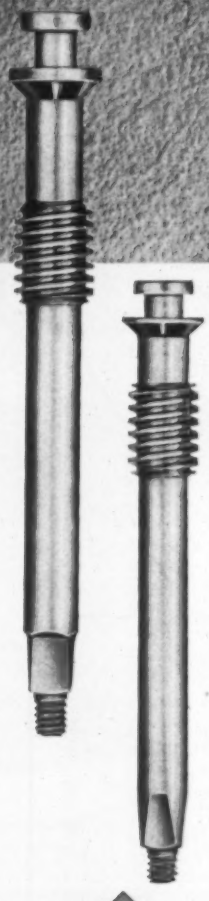
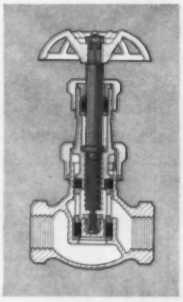




Bridgeport Duronze 707

A tenfold increase in service life... that's the outstanding contribution made by Bridgeport's Duronze 707 to gate valves manufactured by Ohio Injector Company, Wadsworth, Ohio. The big difference is in the valve stems. Duronze 707 not only provides exceptional strength in the stems, but also eliminates risk of seizing or galling. Thread wear is kept to a minimum. In addition, this corrosion-resistant alloy offers an important manufacturing advantage in good machinability.

The toughest valve stems the industry has ever known were evolved through close cooperation between Bridgeport and Ohio Injector metallurgists. This type of cooperation is open to all manufacturers. It means that a *standard* alloy can often be chosen to provide the most effective and economical solution to product or production problems.



Bridgeport Technical Service will gladly advise you on any problems involving metals and their application. Just call your nearest Bridgeport Sales Office—or write directly to Bridgeport Brass Company, Bridgeport 2, Conn., Dept. 3502.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut

Specialists in Metals from Aluminum to Zirconium

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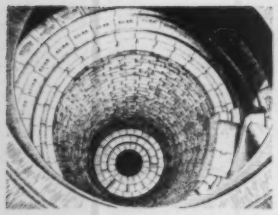
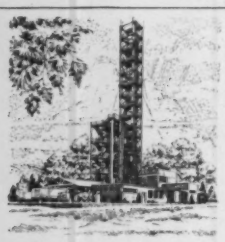
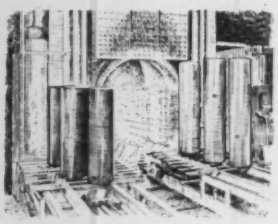


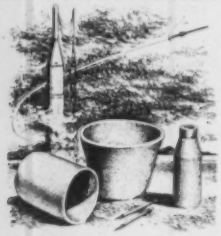
Pebble Heater Linings and Pebbles



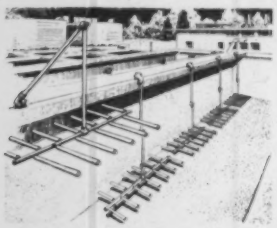
Chemical Reactor Linings



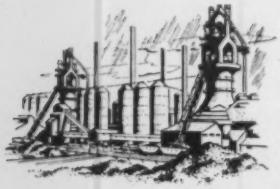
Muffle Plates and Kiln Shapes



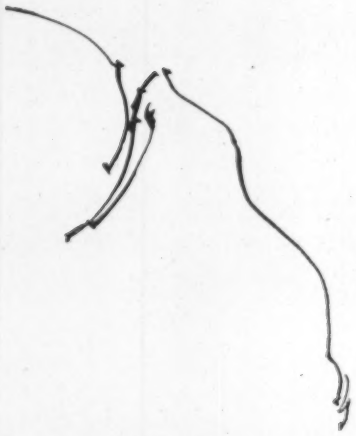
Missile and Rocket Ceramics



Porous Media for Sewage Systems



Wear Resistant Linings for sintering

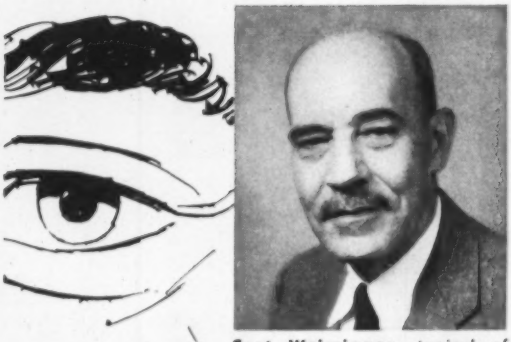


Working with today's imaginative design engineers, Norton Company's "Men with the Facts" are creating exciting new concepts in products and processes. Utilizing the wide variety of physical, chemical and electrical properties of Norton Refractory Materials, they help to solve design problems in products ranging from lightning arrestors to rockets . . . in processes as different as filtration and gas synthesis.

Norton's "Man with the Facts" knows where his company's product can best be applied. Perhaps the high thermal conductivity and high refractoriness of CRYSTOLON* silicon carbide are needed . . . or the excellent chemical stability and abrasion resistance of ALUNDUM* aluminum oxide.

to solve your design problems . . .

NORTON Refractories and the NORTON Man



Curt Weissinger, typical of "Norton Men with the Facts," designed special refractory shapes for a pebble heater to withstand super high temperatures and corrosive conditions. He's also been responsible for successful applications of refractories to reactors, enameling kilns, billet furnaces, missiles and rockets, sewage systems, and other products and processes. Now Supervisor of Norton Refractories Technical Service, Curt has been with the Company for 29 years . . . he's ready to help you in the proper application of Norton Refractory Materials.

Often MAGNORITE* magnesium oxide solves a problem with its high purity and excellent thermal conduction and high electrical resistance. Or, the immunity to oxidation and reduction of zirconium oxide, one of today's highest melting point oxides available in tonnage quantities, may be invaluable.

Find out how Norton Materials and Capabilities can improve *your* product, productive efficiency, and operating economy. Write NORTON COMPANY, Refractories Division, 342 New Bond Street, Worcester 6, Mass.

*Trade-Marks Reg. U. S. Pat. Off. and foreign countries

NORTON
REFRACTORIES
Engineered . . . Rx . . . Prescribed

75 years of . . . Making better products
. . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

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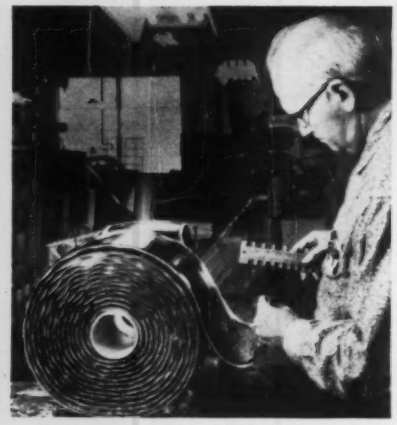
"MIXING TIME CUT 24%"

—Washington Rubber Company

Processor Saves...Recapper Sells



Edward Malone, General Manager of Washington Rubber Company, checks the gauge uniformity of extruded camelback.

Processing costs go down fast when you use Ameripol Micro-Black masterbatch. Edward L. Malone, General Manager, Washington Rubber Company, Washington, Pennsylvania, says, "Switching to Micro-Black has reduced mixing time 24%. The addition of scorch retarders is unnecessary. By eliminating one mixing cycle, we can produce as much as 30% more camelback stock a day."

Washington Rubber finds another processing advantage in the greater tensile strength of Micro-Black masterbatch. "Tensile strength of milled rubber is 3600 psi compared with 3200 psi for the rubber previously used—indicating superior dispersion of carbon black—and a constant Mooney viscosity is obtained," says Mr. Malone.

HERE'S WHY AMERIPOL MICRO-BLACK GIVES SAVINGS LIKE THESE

Goodrich-Gulf's exclusive process—high liquid shear agitation—results in thorough dispersion of black throughout the latex. You get controlled uniformity. You cut your processing costs. You eliminate one complete weighing and milling operation and messy, expensive carbon black cleanup or storage.

with Goodrich-Gulf Micro-Black

"Our customers are consistently averaging 40,000 to 50,000 miles with retreaded tires on the drive wheels of truck tractors, and between 70,000 and 100,000 miles on trailer tires," says John Behan, owner of Anchor Tire Company, Pittsburgh, Pennsylvania.

Crediting the unusually high abrasion resistance of tread rubber compounded with Ameripol Micro-Black for this longer service life, Mr. Behan says, "Despite the beating truck tires take today, tires retreaded with camelback made from Micro-Black rubber are lasting just as long as new tires and at only one-third the cost."

HOW TO PUT MICRO-BLACK TO WORK IN YOUR OPERATION

Call your Goodrich-Gulf Sales Engineer. He'll help you determine the right recipe, will put the Goodrich-Gulf Technical Laboratory at your service. Call today.

FREE

New illustrated data book gives full information on all 10 types of Ameripol Micro-Black, their properties and applications. Send for your free copy.

Goodrich-Gulf Chemicals, Inc.

1717 East Ninth Street, Cleveland 14, Ohio

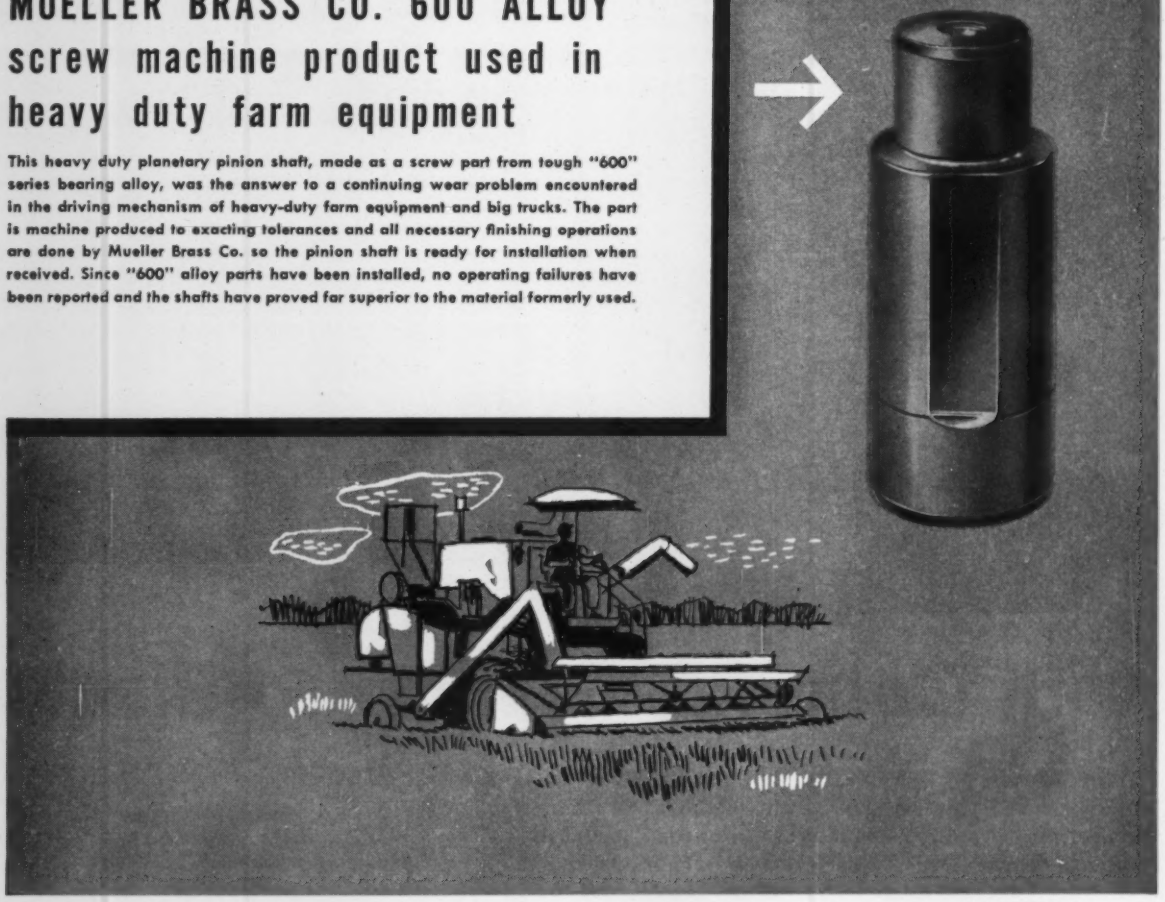
For more information, turn to Reader Service card, circle No. 396

two more cases where **PARTS PRODUCED FROM provide excellent bearing properties**

CASE HISTORY

MUELLER BRASS CO. 600 ALLOY screw machine product used in heavy duty farm equipment

This heavy duty planetary pinion shaft, made as a screw part from tough "600" series bearing alloy, was the answer to a continuing wear problem encountered in the driving mechanism of heavy-duty farm equipment and big trucks. The part is machine produced to exacting tolerances and all necessary finishing operations are done by Mueller Brass Co. so the pinion shaft is ready for installation when received. Since "600" alloy parts have been installed, no operating failures have been reported and the shafts have proved far superior to the material formerly used.



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You get sound, unbiased advice on the one best method of making your parts because Mueller Brass Co. is the only fabricator in the country offering all these methods of production. An experienced Methods Analysis Department has at its command a complete knowledge of the advantages and limitations of each production process. This unique technical service is your assurance of getting the best product at the best price . . . made the one best way!

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PLASTIC INJECTION MOLDING

MUELLER BRASS CO.

MUELLER BRASS CO. 600 ALLOY

and maximum wear resistance in tough applications

CASE HISTORY

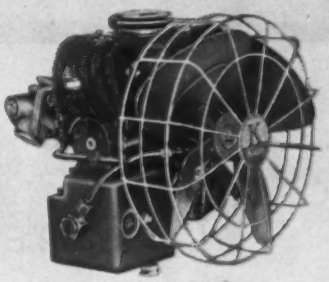
MUELLER BRASS CO. 600 ALLOY forgings used in aviation air compressors

Analyzing the job requirements of Walter Kidde & Company, Inc., for a main driving cam component to be installed in a reciprocating type of aircraft air compressor, Mueller Brass Co. Methods Analysis Engineers decided on a forging fabricated from "600" alloy as the most practical method of production. Since the cam forms the prime component of the driving mechanism, it must have good bearing wear surfaces and because the compressors are used in the aviation industry, the cams must be completely dependable. The close grained, strong forging that resists combination compressive and tensile stresses was the answer.

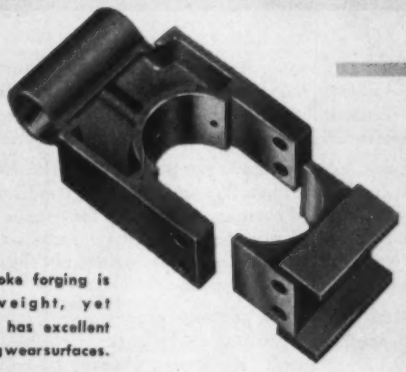
A typical compressor takes in ambient air and compresses it to 3000 psi or higher. This high pressure air is stored in metal or fiberglas containers until needed for actuation of pneumatic system components such as solenoid control valves, brake valves, manual control valves or actuators. These and other pneumatic units retract the entrance door, operate landing gear, wheel brakes, nose wheel steering systems, propeller brakes or perform other functions.

Aircraft in which Kidde compressors are installed include the Boeing 707, the Douglas DC-8, the Lockheed Electra, the Fairchild F-27 and various military aircraft.

Mueller Brass Co. produces press, hammer or cored forgings of any practical shape from a few ounces to 150 lbs. in brass, bronze, aluminum and magnesium in 27 standard, as well as special, alloys.



Aircraft air compressor equipped with hydraulic drive delivers air compressed to 3000 psi at the rate of 6 cfm.

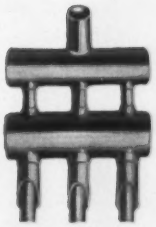


This yoke forging is lightweight, yet strong; has excellent bearing wear surfaces.

Forging is part of the main cam, the prime component of a modified Scotch-type yoke, which is the piston driving mechanism in the air compressor.

POWDERED METAL PARTS

SAND CASTINGS



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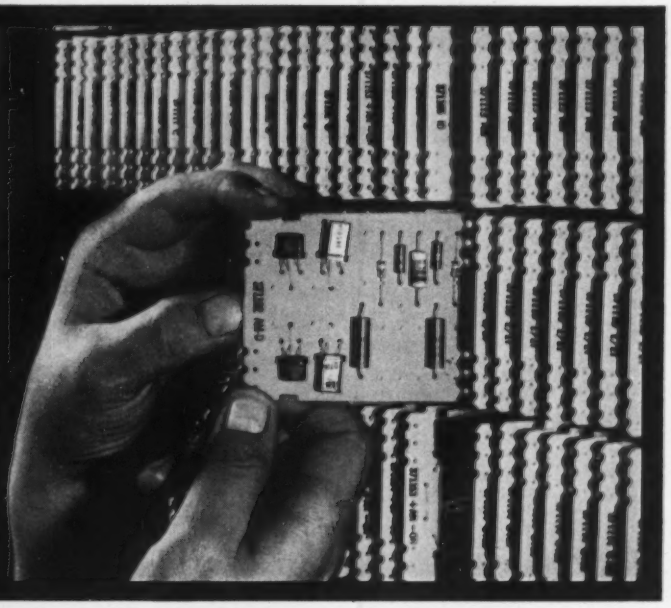

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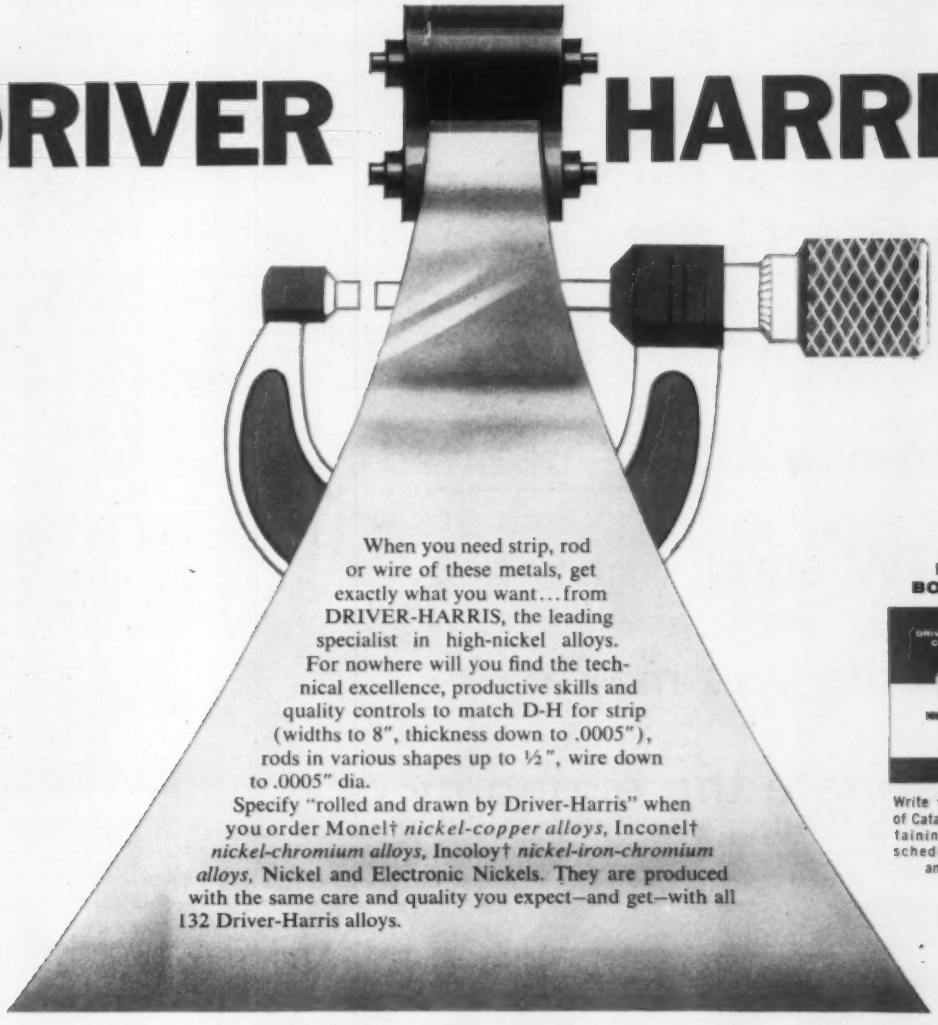

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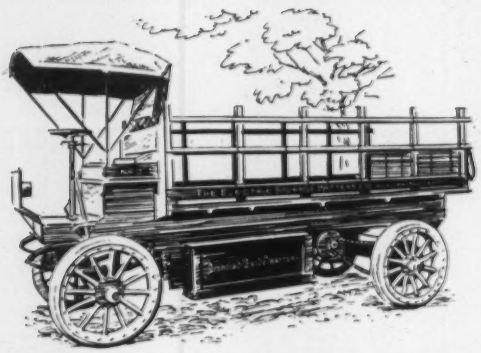
LEAD

Sparks A

RENAISSANCE



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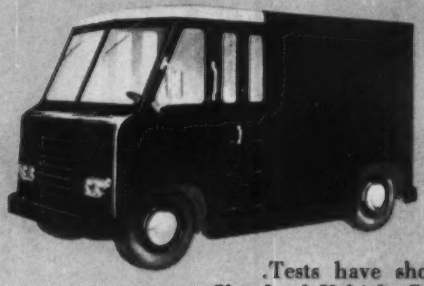

.Tests have shown that this Cleveland Vehicle Company's Electric Delivery Truck for stop-go routes saves up to 50% operating costs . . . up to 55% upkeep costs . . . up to 50% insurance costs.

This is the lead-acid battery powered "Charles Town-About." Low operating cost and upkeep make it the ideal "second" car.

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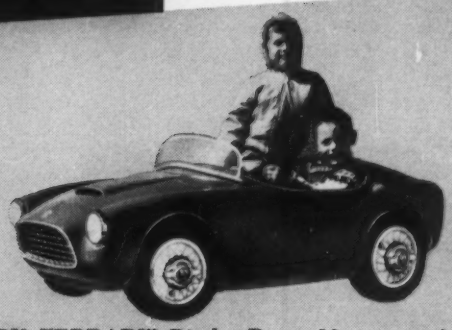

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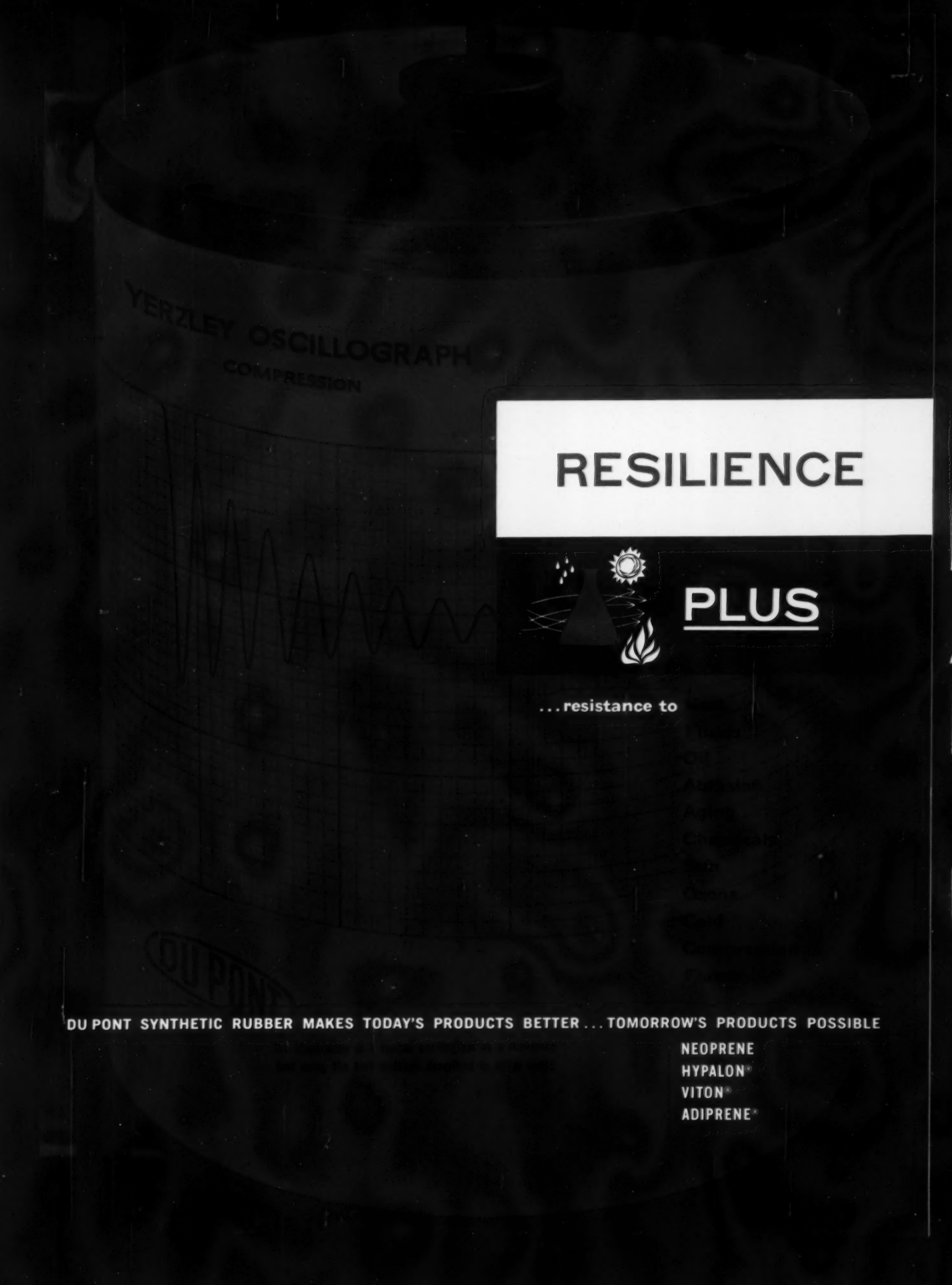

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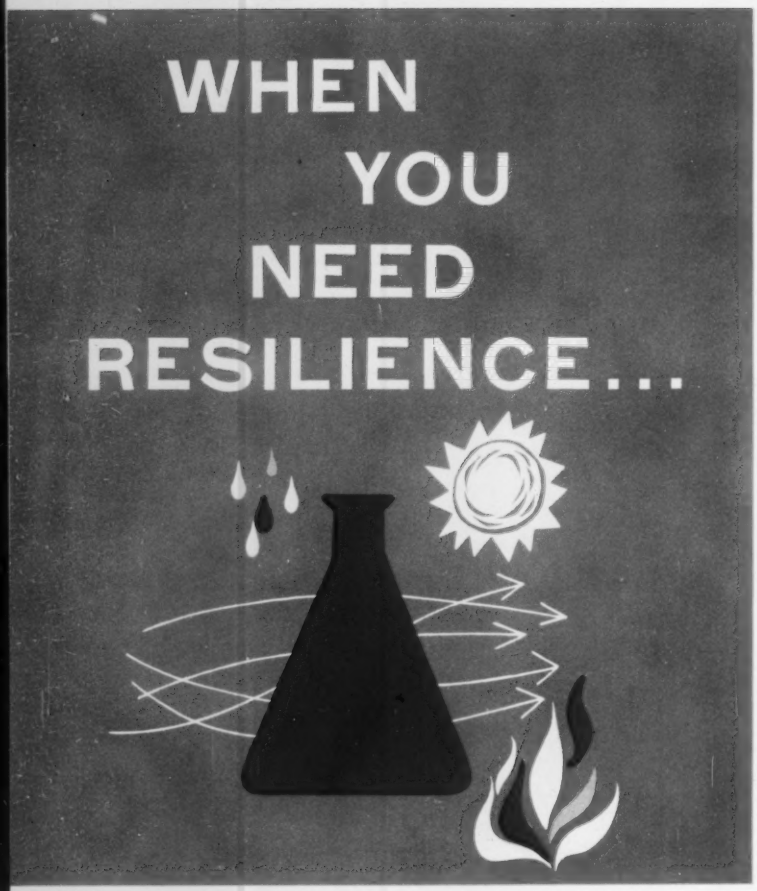

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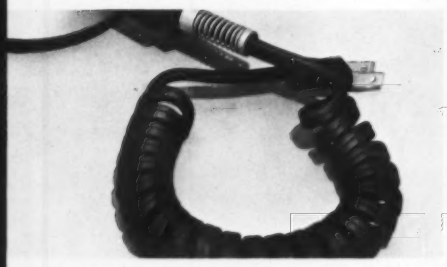
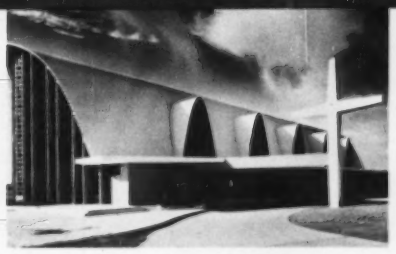


Coiled heater cord for small appliances is jacketed with neoprene for long-term flexibility, resistance to heat, food chemicals and cooking oils. A test cord underwent 500,000 flexing cycles without damage.

Inflatable dam made from tube of neoprene-coated nylon is used in Los Angeles to divert river water for conservation. Test material withstood weather, sun, abrasion from river debris for two years.

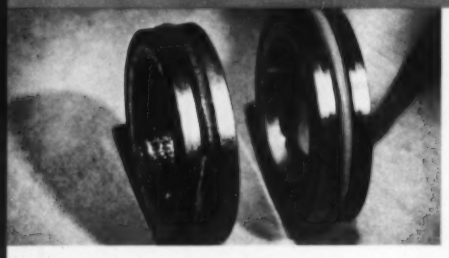
New air valve design for ventilation units is a helical spring covered with neoprene tubing. Neoprene tubing is expected to last as long as the ventilation system and still maintain a tight seal on the close-off.

House-size tarpaulin is used by fumigators to keep exterminating gases from escaping. It is made of nylon fabric coated with Du Pont Hypalon . . . resists sun, weather, fumigating gases . . . is easy to handle.

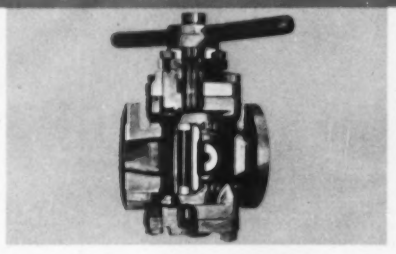


Cathedral roof with sprayed-on coating of Hypalon stays gleaming white in spite of tropical sun, wind, rain and salt spray. Weathering has not caused the reflective roof coating to dull or deteriorate since 1957.

Hypalon shows outstanding resistance to strong oxidizing chemicals. This tubing was used to pump chlorine bleach (5¼% hypochlorite) at 158° F. . . . was still good after a week. Other rubbers failed in 24 hours.

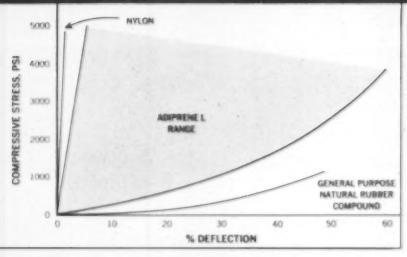


Viton O-rings seal bearings in heat exchanger at 525° F. . . . outlast other synthetic rubbers 25 to 1. They resist fatty acids, dibasic acid, phthalic acid, solvent and petroleum products . . . maintain their resilience.

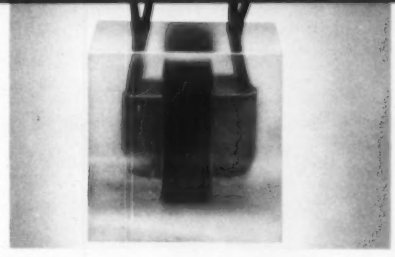


This refinery valve has been used in a benzene line for over a year. Its O-rings and valve seat —made from Viton—are still assuring positive shut-off. Viton parts also resist toluene, xylene, 380° F. alkylate gas, 400° F. propane.

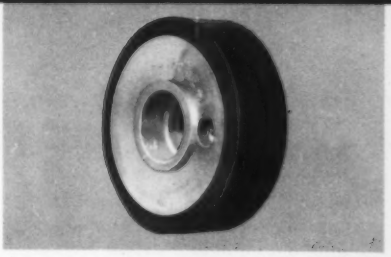
Fire seals in the wings of the new B-58 "Hustler" are made from Viton-coated asbestos fabric . . . resist heat, ozone, jet fuels, fumes and corona . . . are equivalent to stainless steel in fireproofing qualities.



Load-bearing capacity of hard Adiprene L compounds ranges between that of general purpose rubber and the harder plastics. You might use Adiprene L compounds to replace non-elastomeric materials where cushioning or damping properties are needed.



Adiprene L can be used alone or in combination with epoxy resins for potting and encapsulating electrical assemblies. Its flexibility helps protect delicate instruments from damage. It has excellent resistance to thermal shock.



Industrial wheels made of Adiprene L outlast rubber and plastic . . . are outstanding in abrasion resistance. They resist oils, mild acids and alkalies, temperature extremes, weathering and aging . . . are resilient and non-marring.

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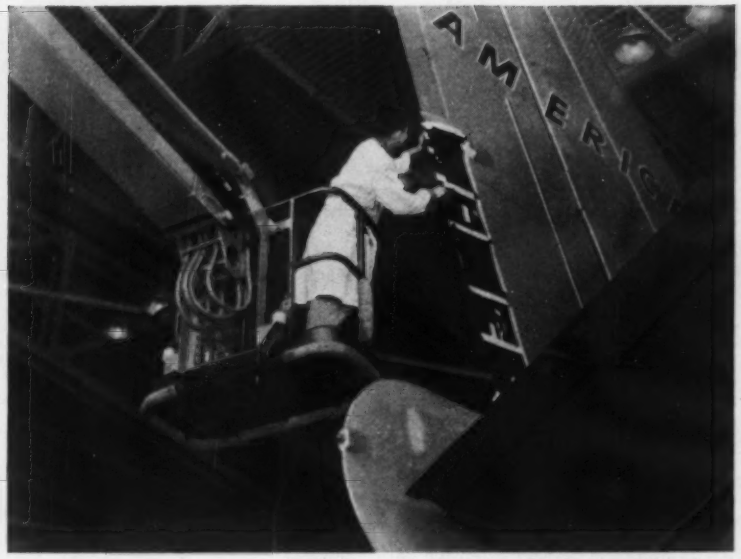
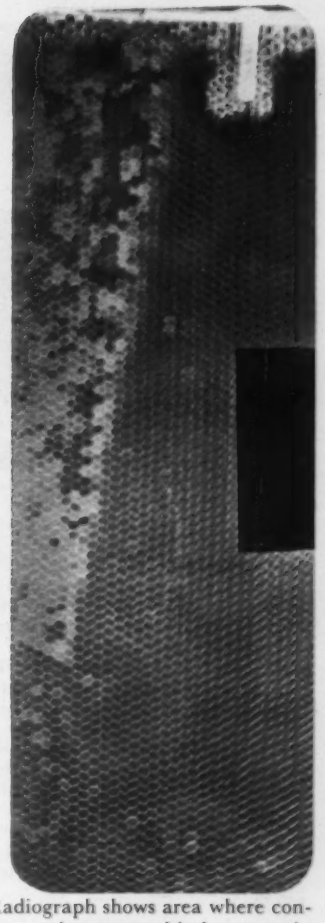


Technician of New York Testing Laboratories places Kodak Industrial X-ray Film, Type AA, in position.



Radiograph shows area where condensate is entrapped in honeycomb.

Keeping tab on trim tabs

Rigid inspection of American Airlines' jets includes radiography of trim tabs to reveal any accumulation of water from condensation.

At the altitude and speeds which jet aircraft fly, temperature changes are frequent. This often means condensation—sometimes water accumulation in the honeycomb construction of the trim tabs.

This is something American Airlines keeps track of in its periodic rigid inspections. Best way is by radiography. And New York Testing Laboratories was one company given the assignment.

With a mobile X-ray unit, and using Kodak Industrial X-ray Film, Type AA, the inspection is made quickly and a lasting record obtained.

In such inspections of assemblies, in quality control, nondestructive testing, radiography provides a means of determining internal conditions.

Producers of castings and makers of welded products find radiography a means of expanding their business and making sure only quality work is delivered to the customer.

Would you like to learn how radiography could help you? Contact your Kodak X-ray dealer or write us for a Kodak Technical Representative to call.

Read what Kodak Industrial X-ray Film, Type AA, does for you:

- Speeds up radiographic examinations.
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the LEAD newsletter

Name your technological field . . . electronics, thermoelectrics, cryogenics, atomic energy, chemicals, construction, ceramics, or whatever . . . it's safe to assume that ubiquitous lead plays a vital part in some facet of it. One reason why lead is found in so wide a variety of uses is *research*. The Lead Industries Association is sponsoring a worldwide cooperative research program in lead conducted in universities, private and public research institutions and individual companies. This is in addition to heavy research expenditures on lead conducted by companies both in and outside of the lead industry and governmental agencies. To keep lead one step ahead of the latest technological developments, LIA also makes every effort to keep informed on all lead research, both its own and that of others. Some areas of current intensive investigation . . . and the results already achieved . . . are outlined in the following paragraphs.

Electronics

Ultra low-loss lead-fluxed ceramic dielectrics have already been perfected by LIA-sponsored research and put to use by commercial electronics manufacturers. Currently, LIA-sponsored research in this field is centered on developing a new ultra low-loss ceramic dielectric incorporating alumina as the main crystalline compound.

Lead piezoelectrics have opened the doors to many applications involving conversion of electrical to mechanical energy and vice versa. Stereophonic pick-ups, for example, have been made of lead zirconate-titanate. This material also greatly increases the operating range of missile devices, sonar transducers, ultrasonic equipment, and many other systems.

Vibration

Although lead has been known as a vibration damp for many years, LIA-sponsored research is designed to develop engineering data which it is expected will add new dimensions to lead's effectiveness in vibration control. Lead asbestos pads, for instance, were used in the foundations of the new Union Carbide skyscraper in New York . . . right over the dense network of railroad tracks leading into Grand Central Station! And, for the first time, they have been used to isolate vibration of a roof-top air-conditioning cooling tower on a New York skyscraper.

Organolead Chemicals

LIA is financing several extensive research projects, both here and abroad, in the field of lead chemicals with particular emphasis on organolead compounds. While tetraethyl lead has long been the shining example of commercially valuable organometallics, many other organolead compounds are being synthesized and their properties studied for industrial usefulness.

Cryogenics

A large amount of scientific study is being devoted to the amazing conductivity properties of lead at temperatures several hundred degress below zero. At this point, lead does a complete about face from its normal characteristics of being a poor conductor of electricity and becomes a superconductor. Researchers are currently at work to capitalize on this phenomenon in computers and similar equipment which, as a result, might be significantly reduced in size.

Emissivity

Certain lead compounds . . . such as PbSe, PbS, PbO, and PbTe . . . have exhibited interesting heat emissive properties. Basic research is being conducted into the why's and wherefore's of this performance . . . and the possibilities of utilizing these properties to improve the efficiency of commercial heating and refrigeration systems. To date, the work has been concentrated on obtaining the room temperature emission properties of lead telluride, which is expected to have the highest emissivity of the compounds under consideration.

Ceramics

Research in a variety of ceramic applications has already brought on the market several new and useful products such as lead-containing porcelain enamels for coating aluminum . . . lead glazes on bricks and light aggregate blocks . . . and leaded porcelain enamel for coating chalkboards made of thin steel. Current research is intensively investigating the wettability of lead glazes on structural clay bodies with respect to clay body composition, lead composition of the frit, and firing atmosphere, and low-firing porcelain enamels for steel.

Sound

While lead is already noted as a sound isolation medium . . . heavily leaded plastics are currently being used for this purpose in the latest jet aircraft and helicopters . . . a continuing project is currently underway that entails a feasibility study for employing lead products in architectural structures for sound isolation.

Anodes

Impressed current systems . . . for the protection of iron and steel against corrosion . . . are coming under much study by industry. Lead alloy anodes are showing exceptional results in research programs dealing with this subject. Already, installations have been made on ships, piers, bridges and other structures.

No matter what *your* problem, there's a good chance that lead may well provide your best solution. Why not find out? All you need do is write for the free advice of our scientists and researchers. The address: Office of Technical Information, Lead Industries Association, 60 East 42nd Street, New York 17, N.Y.

2164

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PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Something extra in molding compounds**
- **Fire-retardant structural plastic**
- **News notes for designers**

Upgrading a product

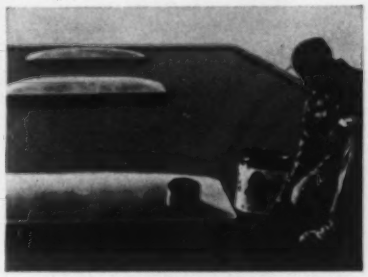
Good • Plenty of distributor caps are molded of Durez general-purpose phenolic. When cost is a prime factor, general-purpose does the job and does it well.

Best • However, if you're shooting for something extra in a distributor cap (or in almost any electrical part), take a look at *Durez 2271*. This is an electrical-grade phenolic. A ⅛" test disk of it withstands 12 kv at 180° F in air for an hour or more without puncturing. The cost of this extra performance is low: weighing less than comparable electrical-grade materials, *2271* gives you more pieces per pound.

Good • You'd be right in choosing *Durez 791 Black* for a piece like this telephone handset. You'd be able to count on low molding cost because of *791's* fast cure. You'd get the required physicals in good balance. And the price of this wood-flour-filled material is low.

Best • Then why do telephone men favor a different material, *Durez 17225*, for handsets? Because this wood-flour-and-flock-filled material provides even higher resistance to impact fractures. The rich black finish presents an unyielding front to moisture and body acids. Bonus: a part that *more* than meets the specs—for fractions of a penny per piece.

We could go on and on giving you case histories like these. Have you looked into the extras you can build into a product—at next-to-invisible cost—with Durez molding materials? To get a better idea of what these compounds can do for you, send for our illustrated 8-page Bulletin D400 listing properties, uses, advantages.



CONSOLITE (CONSOLIDATED GENERAL PRODUCTS, INC.)

Safer skylight

Here's a plastic skylight that retards fire.

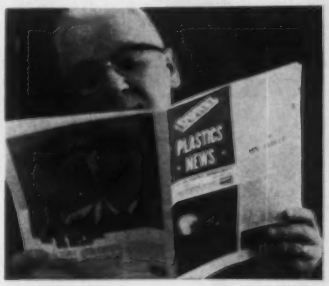
It's made for use in hazardous locations or wherever building codes are exceptionally strict.

The material is fibrous-glass-reinforced Hetron®. It will ignite only under direct hot flame, and snuffs out as soon as the flame source is removed.

Weighing only half a pound per square foot, the skylight material will support a uniform load of 150 pounds per square foot. It is thermally stable from −65° to 200° F, and has great strength and shatter resistance even at subzero temperatures.

Its thermal conductivity is only ⅕ that of glass, yet it can transmit ⅘ as much light as glass without glare. It delivers greater insulating effect than other skylight materials, at lower cost.

Could any of these attributes help *you* design a better product? Hetron® is hard at work already in radomes, chemical ducts, blowers, boat hulls, housings, fume hoods, window panels, canopies. Data on self-extinguishing Hetron resins is yours for the asking.



On keeping abreast

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To get this bimonthly packet of ideas and information, just check the coupon.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic molding compounds (8-page Bulletin D400).
- ☐ Hetron fire-retardant polyester resin (data file).
- ☐ *Durez Plastics News* (mailed bimonthly).

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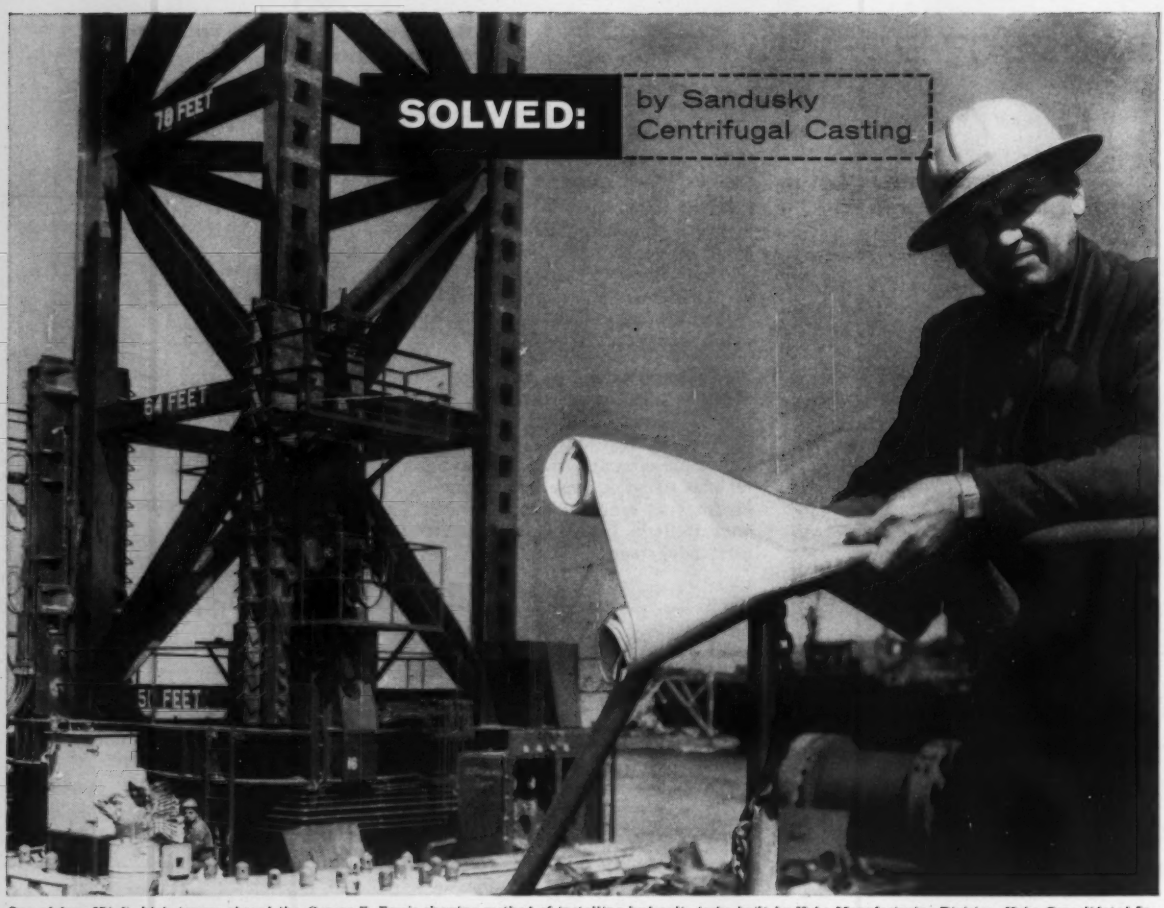

One of four 274 ft. high towers aboard the *George F. Ferris* showing method of installing hydraulic jacks built by Yuba Manufacturing Division, Yuba Consolidated Industries, Benicia, Calif. George Bauer, of Delong Corp., New York, is shown supervising construction while platform is being completed at Yuba's Richmond, Calif., plant.

YUBA gets quality-cost-delivery advantages by specifying 16 Sandusky cylinders

Sixteen 500-ton hydraulic jacks built by Yuba, for which Sandusky supplied the main cylindrical bodies, enable the new pipe-laying barge, *George F. Ferris,* to operate in waters 200 ft. deep!

This 5400-ton barge is equipped with four structural steel towers 274 ft. high. Four jacks on each of the towers provide the power to lower these steel "legs" to the ocean floor, raise the barge above the surface of the water, or retract the towers to render the barge navigable. The steel jack cylinders are Sandusky Centrifugal Castings, made to the requirements of ASME Code-approved SA-217, Section VIII, Unfired Pressure Vessels, to withstand operating pressures of 3000 psi. They were produced in 186″ lengths, machined to 24″ O.D. with 2″ thick walls and sectioned into four pieces 43″ long.

Yuba's selection of Sandusky Centrifugal Castings was based largely on three essential factors: QUALITY—meeting the exacting Code requirements . . COST—saving about half the cost of an alternate method of manufacture . . and DELIVERY—coming through on a tough time schedule by delivering all 16 cylinders within 21 working days!

When you need cylinders from 7″ to 54″ in O.D. and up to 33 feet long it will pay you to get in touch with us. Write for our latest booklet, *Your Solution To Cylindrical Problems* containing data on more than 70 ferrous and non-ferrous alloys.

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FOUNDRY & MACHINE CO.

5902

SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

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ENGINEERING & DESIGN

...AT A GLANCE

Cold drawing significantly increases the strength of nickel at temperatures up to 900 F, recent research indicates. The strengthening effect disappears when the cold drawn metal is exposed to higher temperatures.
Source: National Bureau of Standards, Dept. of Commerce, Washington 25, D. C.

Epoxy coatings have better resistance to corrosion than alkyd, phenolic and other coatings after being exposed to air, water, industrial fumes and sunlight for five years. Outdoor aging tests show that film deterioration of an epoxy coating follows a pattern of loss of gloss, followed by checking, blistering or peeling, but never by undercutting of the coating by rust or corrosion.
Source: D. E. Floyd and D. Glaser, General Mills, Inc., 2010 E. Hennepin Ave., Minneapolis 13, Minn.

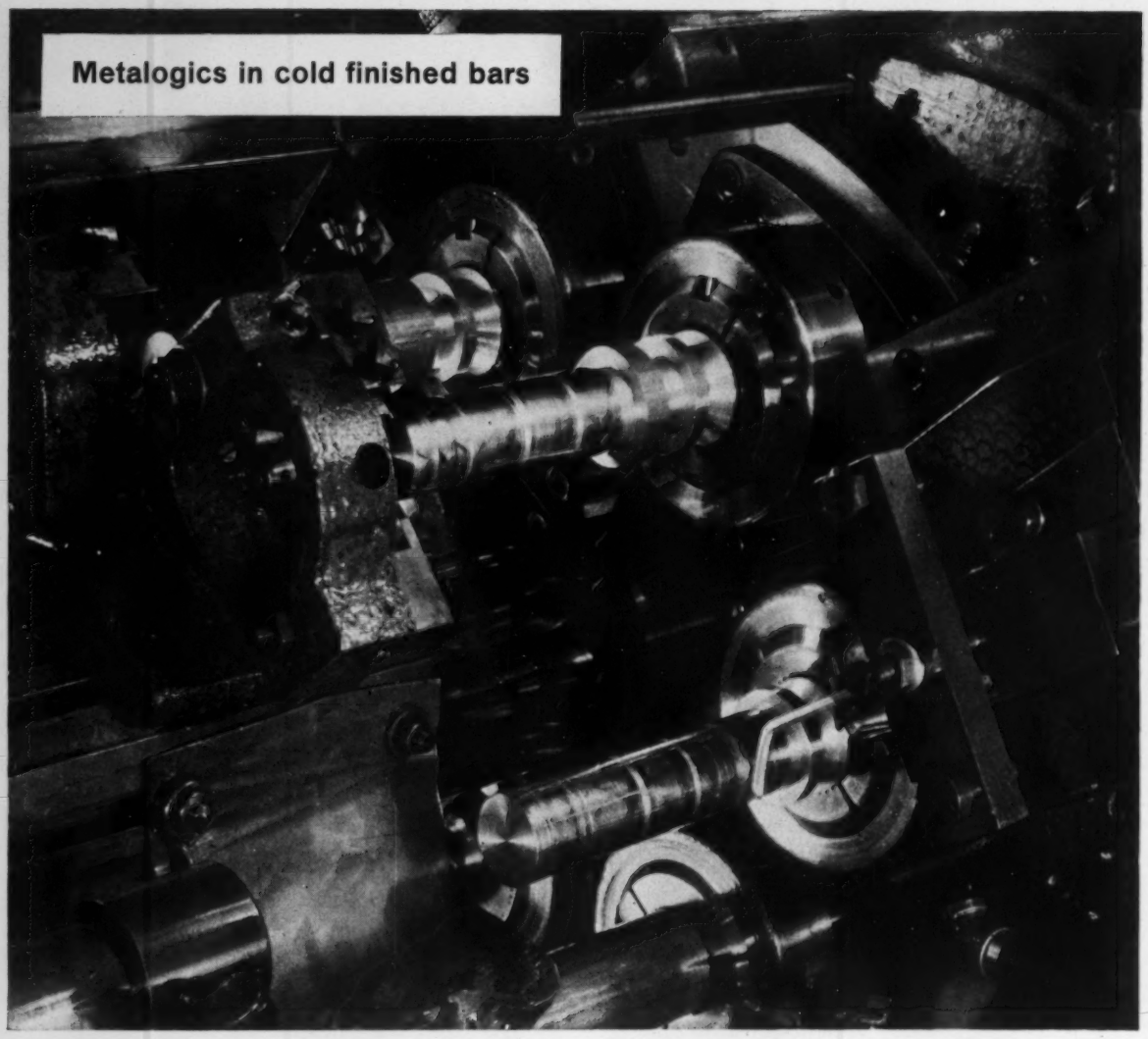
'Hot cracking' tendencies of metals can be predicted accurately and quickly by a new test that can be completed in a "matter of minutes," according to a Westinghouse report. Details have not been revealed. Conventional tests usually require weeks or months to complete.
Source: F. C. Hull, Westinghouse Electric Corp., 3 Gateway Center, P. O. Box 2278, Pittsburgh 30.

Aging characteristics of rubber vulcanizates at various temperatures can best be evaluated by using elongation data. Tests show that elongation decreases during aging for all types of rubber vulcanizates, whereas tensile strength and modulus may increase, decrease, or remain essentially unchanged.
Source: J. Mandel, et al., National Bureau of Standards, Dept. of Commerce, Washington 25, D. C.

An improvement in the structure of cast iron—in the form of more large graphite flakes—can be obtained by adding small amounts of calcium to molten iron, recent research indicates. The calcium reacts with carbon in the iron to form calcium carbide particles on which the graphite flakes grow. Large graphite flakes give iron machinability, wear resistance and many other valuable properties. Previously, silicon was used to promote graphite flake growth in cast iron.
Source: H. L. Womochel, Michigan State University, East Lansing, Mich.

More meaningful data on environmental stress cracking of polyethylene can be derived from a new test in which a constant stress is applied to test specimens. In previous methods the stress was not held constant from specimen to specimen but was varied with rigidity of the molded resin being tested. The developer says the new test method can be used to evaluate polyethylene of any density or degree of flexibility.
Source: L. L. Landers, Union Carbide Plastics Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17.

Wear resistance of various electroplates can be improved by alloying with molybdenum. Wear resistance of a hard chromium electroplate alloyed with 1% molybdenum was increased 3 to 8 times over that of an unalloyed hard chromium electroplate. Molybdenum has also been found to improve hot hardness, and magnetic and electrical properties of various electroplates.
Source: Literature survey by J. Z. Briggs and H. W. Schultze, Climax Molybdenum Co., 500 5th Ave., New York 36.



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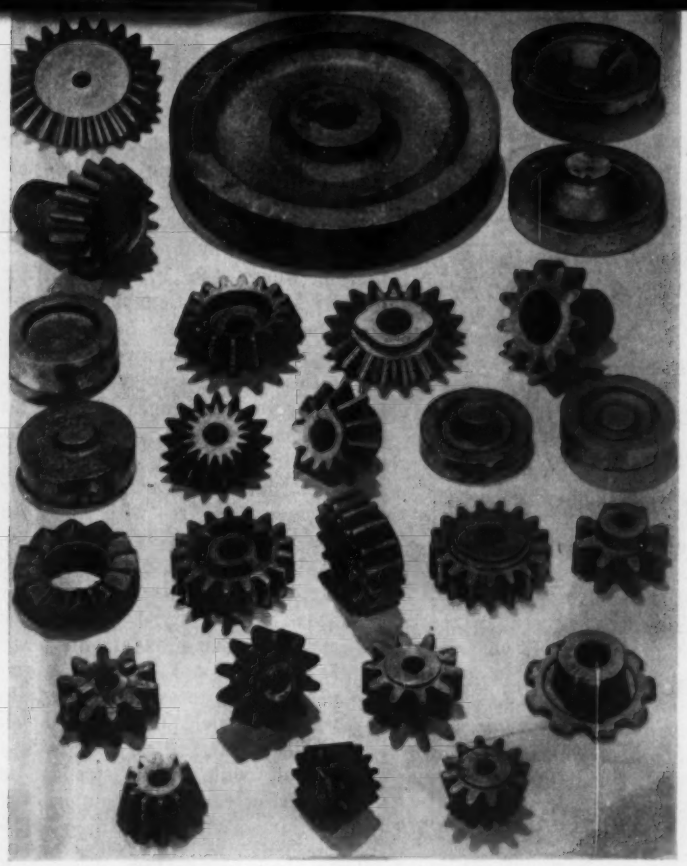


Gears *of hardened pearlitic malleable iron resist wear.*

Here are the latest data on pearlitic malleable irons, adapted from the Malleable Iron Castings Handbook *just published.**

Properties of Pearlitic Malleable Irons

■ Because of its excellent castability, high strength, good properties at elevated temperatures, resistance to fatigue, adaptability to surface and through hardening, wear properties, and ease of machining (with excellent surface finish), pearlitic malleable iron is specified for applications in which long, rigorous service is required. Virtually every major industry uses pearlitic malleable castings extensively for parts such as gears, connecting rods, armament components, chain links and sprockets, Diesel pistons and valve elements, camshafts, crankshafts and transmission parts, to name only a few representative examples.

What is pearlitic malleable iron? The term is applied to the class of malleable iron which, by special processing, contains temper graphite nodules and some 0.3-0.9% combined carbon in closely controlled quantity, form, and distribution throughout the matrix. It is distinguished from the ferritic grades of malleable iron by the combined carbon found in the matrix (from which the characteristic qualities of pearlitic malleable castings arise).

Room temperature properties

Tensile properties

Pearlitic malleable irons are available with a wide range of tensile properties. Generally, the high strength grades have relatively low ductility, and the high ductility grades have intermediate strength properties. Tensile strengths of 65,000 to 120,000 psi or higher, yield strengths of 45,000 to 100,000 psi or higher, with elongations of 16 to 2% in 2 in. are obtainable in the grades regularly produced. Table 1 lists minimum tensile requirements for seven grades of pearlitic malleable iron specified by ASTM.

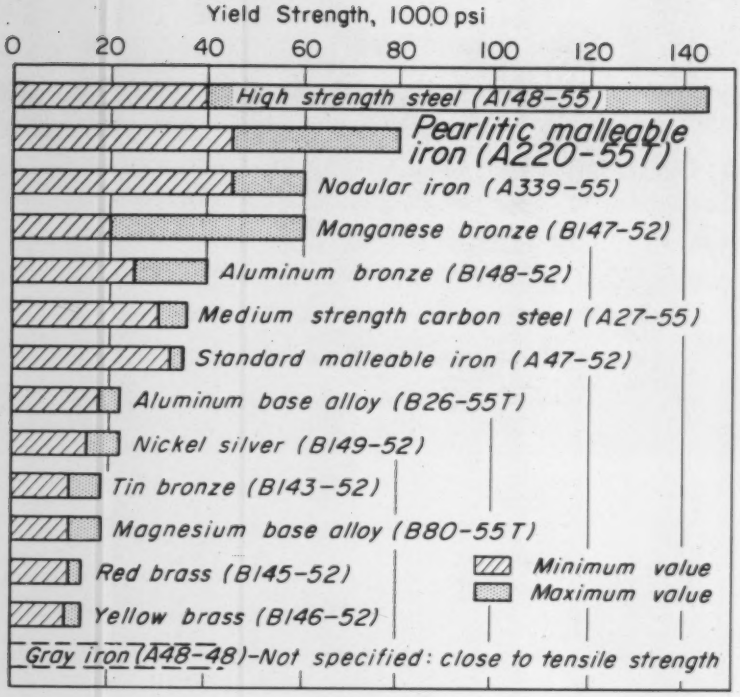
Yield strength is generally

TABLE 1—TENSILE PROPERTIES OF PEARLITIC MALLEABLE IRON[a]

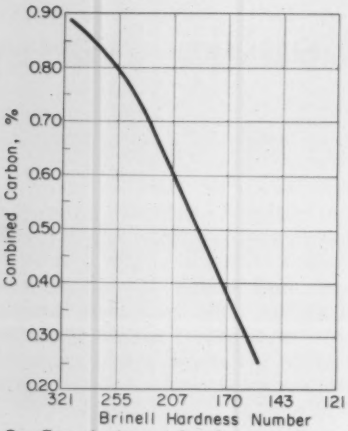
Grade ↓	Ten Str (min), psi	Yld Str (min), psi	Elong (in 2 in., min), %
45010	65,000	45,000	10
45007	68,000	45,000	7
48004	70,000	48,000	4
50007	75,000	50,000	7
53004	80,000	53,000	4
60003	80,000	60,000	3
80002	100,000	80,000	2

[a]As required by ASTM A220-55T.

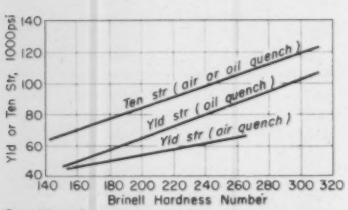
* Published by the Malleable Founders Society in Feb '60.



1—Minimum yield strength of some cast alloys, as specified by ASTM.



2—Correlation of hardness and carbon content of pearlitic malleable iron.



3—Hardness vs yield and tensile strengths of pearlitic malleable iron.

specified either at an offset of 0.2% or at an extension under load of 0.5%. Yield strengths of pearlitic malleable irons are compared graphically with specified values for other ferrous and nonferrous metals in Fig 1.

The ratio of yield strength to tensile strength is 0.65 to 0.9, the ratio for high-tensile-strength irons being in the upper part of this range. The modulus of elasticity of representative pearlitic malleable irons is 25.5-28.0 $\times$ 10^6 psi.

Hardness

Selection of the grade of pearlitic malleable to be used in a particular application may be determined by the hardness required in service. Since pearlitic malleable castings are used in so many components subject to frictional wear and abrasion, such as gears and rocker arms, the wide range of hardness available in the material is important.

Brinell hardness numbers common to the ASTM grades of pearlitic malleable range from 163-269. In addition, surface or through hardening can be performed.

Where the specimen is too small to be tested by the Brinell method, or where the Brinell indenter might be objectionable on a finished surface, the Rockwell test may be used. Rockwell B and G scales may be employed satisfactorily for the ranges of hardness common to most pearlitic malleable irons.

Hardness of pearlitic malleable castings increases with combined carbon content. This is illustrated in Fig 2 which plots combined carbon content vs Brinell hardness for one type of pearlitic malleable that was air quenched from 1680 F and tested after tempering. Hardness is related to tensile and yield strength as shown in Fig 3. It can be seen in Fig 3 that, while tensile strength is not affected by the quenching medium, yield strength is influenced, particularly at the higher hardness levels.

Fatigue strength

It was determined in one study that the fatigue ratio for pearlitic malleable is approximately 0.40. Fifty-five unnotched fatigue specimens were machined from standard tensile bars cast from the same ladle of duplexed white iron, which was converted into three sets of pearlitic malleable of approximately the same hardness by three different heat treatments. After running the specimens at 7000 cycles per min on a Krouse rotating beam machine, the fatigue limit was found to be 40,000 psi at 10 million cycles. Tensile strength of the specimens averaged 100,000 psi.

In another study, at the University of Illinois, the median fatigue limit for a pearlitic malleable iron was found to be 32,650 psi in reversed torsion. Ninety-five per cent of all specimens would be expected to survive 10 million cycles at 30,300 psi (see Fig 4). Specimens were made from a duplexed, high strength, oil quenched and tempered pearlitic malleable iron and had a test section 0.250 in. in dia $\times$ 0.875 in. long. These were machined from

1 in. dia × 6 in. long bars. Testing was performed at a constant amplitude torsional deflection, operating at 1730 cycles per min. Seven specimens which did not fail after 10 million cycles were rerun at higher stress levels to obtain additional finite life data.

Notch sensitivity—Prior to accepting pearlitic malleable iron as a replacement for forged AISI 1046 steel crankshafts, one automobile manufacturer ran dynamometer tests on the two materials and obtained comparable fatigue properties. Notched impact fatigue tests were also run on specimens machined from the counterweights of pearlitic malleable crankshafts. Angle of the notch was varied from 10 to 30 deg. Notch sharpness did not affect the fatigue test results.

Shot peening—Fatigue life of pearlitic malleable iron is extended manyfold by adequate shot peening in critical locations to place the surface in compression. The degree of this improvement depends upon the type of fatigue loading, the design of the casting, and the efficiency of the shot peening operation. Maximum benefits are obtained if particular attention is given to those surfaces that are to be subjected to the greatest tensile stresses. In one series of tests, the life of pearlitic malleable specimens was increased some 50 times by shot peening (see Fig 5).

Damping capacity

The specific damping capacity (the ratio of the energy lost in one vibration cycle to the total energy of that cycle, expressed as as a percentage) of pearlitic malleable irons has been determined from three sets of specimens: one made by air cooling and tempering to a hardness of 223 Bhn, and two others made by oil quenching and tempering to hardnesses of 212 Bhn and 255 Bhn, respectively. All three materials gave almost identical results.

When stress levels increased from 5000 psi to 35,000 psi, specific damping capacity increased from approximately 1.9% to 5.3%. Pearlitic malleable can therefore be expected to damp out vibrations somewhat better than Grade B cast steels and nodular cast irons, but not quite so well as standard malleable.

Shear strength

Shear strength determinations were made on a series of pearlitic malleable irons that ranged in tensile strength up to more than 125,000 psi. Values for shear strength from 65,700 psi to 102,-550 psi were obtained. Shear strengths thus fell within 70 to 85% of the tensile strengths.

Torsional properties

Torsional properties of pearlitic malleable irons were determined by ASTM A260-47, using multiple samples of all the grades. Modulus of rupture was found to be approximately equal to the tensile strength of the material. Modulus of elasticity in torsion was found not to vary with the grade of pearlitic malleable, averaging 9.97 × 10^6 psi (range 8.79 × 10^6 psi to 10.71 × 10^6 psi). Yield strengths in torsion ranged from 24,500 to 82,300 psi, and

How Pearlitic Malleable Is Made

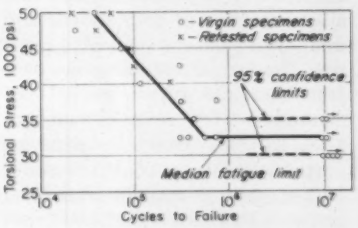
The manufacture of pearlitic malleable iron starts with the production of white iron castings in which the carbon is in the combined form. These are basically the same white iron castings that are converted into standard malleable by a malleablizing heat treatment. (In the manufacture of one general type of pearlitic malleable iron, however, the metal composition is altered by alloying to facilitate heat treatment, to improve certain properties, or both.)

The second step in the pearlitic malleable process, heat treatment, starts out as in the production of ferritic or standard malleable castings. In all grades of pearlitic malleable iron, first-stage graphitization is carried to completion. Thereafter the processing departs from the usual malleablizing treatment in one of two ways:

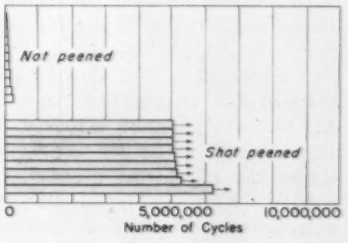
1. The controlled rate of cooling through the eutectoid range is kept rapid enough to retain a desired amount and type of combined carbon in the matrix. Liquid or air quenching and closely regulated furnace cooling are two ways employed to obtain this transformation product.

2. Pearlitic malleable is produced by reheat-treating fully malleablized castings to recombine a desired quantity of carbon and retain it in the matrix.

Whatever the method, approximately 0.3 to 0.9% combined carbon — depending upon the properties desired in the particular grade—is retained in the matrix of pearlitic malleable castings. Higher strength and hardness requirements generally necessitate controlled combined carbon in the upper part of the range. In most grades the matrix is later modified by a further treatment which tempers the as-quenched structure, raises its ductility, improves machinability, and increases uniformity.



4—*S-N curve for torsional fatigue loading of pearlitic malleable iron.*



5—*Effect of shot peening on fatigue life of pearlitic malleable iron.*

TABLE 2—CANTILEVERED UNNOTCHED IMPACT PROPERTIES

Ten Str, psi	Yld Str, psi	Elong (2 in.), %	Bhn	Impact Str, ft-lb
69,500	47,100	11.0	163	68.3
81,100	54,650	13.0	183	82.7

TABLE 3—TENSILE IMPACT PROPERTIES

Ten Str, psi	Yld Str, psi	Elong (2 in.), %	Bhn	Ten Impact Str, ft-lb
85,000	56,400	15.0	204	84.3
85,700	56,900	8.0	207	62.2
90,100	64,700	9.0	212	67.3
106,400	90,400	4.5	277	31.0
123,100	111,500	2.5	311	19.5

varied inversely with angle of twist (363 to 69 deg).

Compressive strength

Compressive yield strength is approximately equal to yield strength in tension for pearlitic malleable irons. Both compressive strength and modulus of elasticity in compression are independent of other properties. Compressive strength ranges from 197,000 to 290,000 psi for specimens ranging in hardness from 180 to 340 Bhn. Compressive strength may be increased by supplementary heat treatment. Modulus of elasticity in compression is approximately 23.2×10^6 psi.

Impact resistance

There is no universally accepted test for evaluating the impact resistance of all materials. Test results are affected by method of loading, presence or absence of stress-raisers and their geometries, size and shape of the test specimen, and temperature. A number of different procedures have been employed for evaluating impact properties of pearlitic irons. Some of the results:

Cantilevered unnotched—Specimens of two pearlitic malleable materials, one made by batch melting, the other by duplexing, were tested at room temperature. The averaged values for 0.505-in. dia bars are shown in Table 2.

Charpy V-notch—Bars of spheroidized pearlitic malleable iron gave maximum values up to about 14 ft-lb. While this may seem to be a relatively low energy value, the material exhibited tough or ductile-type characteristics when subjected to shock loading. Brittle-type fracture developed when impact values dropped to about 4 or 5 ft-lb and temperature was lowered. Charpy unnotched tests on both air cooled and oil quenched pearlitic malleable specimens gave impact values of 22 to 35 ft-lb.

Tensile impact—Tests at 76 F carried out with specimens conforming to Type V, Fig 9 of ASTM E23-47T (appendix) resulted in the averaged properties shown in Table 3.

Effect of temperature

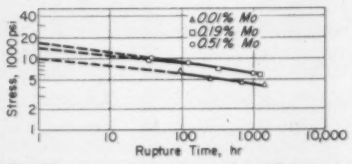
Short time tensile properties

The effect of high temperature exposure on the hardness and tensile properties of both alloyed and unalloyed pearlitic malleable irons was investigated using a base iron that was duplex melted and contained 2.6% total carbon and 1.4% silicon. Room temperature properties of the pearlitic malleable specimens were 90-92,000 psi tensile strength, 60-72,000 psi yield strength, 4% elongation in 2 in., and 229 Bhn. When this iron was heated to 1000 F, held for 1 hr at temperature, and tested, tensile and yield strengths of the unalloyed pearlitic malleable dropped to 46-47% of their room temperature values; elongation increased to 14% in 2 in., or 350% of room temperature values. At temperatures of 1100 and 1200 F and at longer exposure times, the effect was even more marked. However, metal alloyed with about 0.3% or more molybdenum showed much better stability at elevated temperatures even after 1000 hr exposure. The alloy addition served to stabilize the pearlitic matrix and to strengthen the structure.

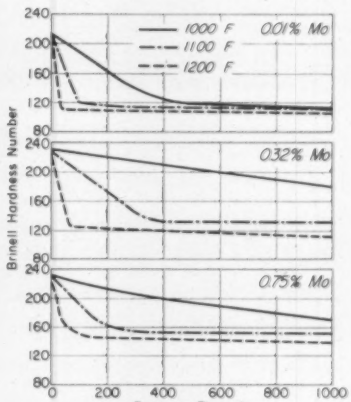
While there may be a small decline in tensile strength of some pearlitic malleable irons at temperatures up to about 300 F, it may be generally concluded that normal room temperature tensile strengths will prevail up to 700 F, above which strength falls off and ductility rises.

Stress–time to rupture

Effect of the molybdenum alloying addition is further shown in Fig 6. Both alloyed and unalloyed pearlitic malleable irons made by air quenching and tempering to 229 Bhn were tested at 1100 F to obtain the values presented. After 100 hr the unalloyed specimens ruptured at 6000 psi; after 1000 hr rupture occurred at about 4200 psi. Stress-time to rupture values for the molybdenum-alloyed pearlitic malleable irons were about 40% higher than those for the unalloyed irons.



6—*Stress-rupture is affected by alloying.*



7—*Alloying helps maintain higher hardness at elevated temperatures.*

Hardness

In short-time exposure tests (15-20 min), hot hardness of three different grades of air quenched and tempered pearlitic malleable iron dropped slightly between room temperature and 200 F, but was fairly constant between 200 and 800 F. Above 800 F, hardness fell markedly.

Hardness of both unalloyed and molybdenum-alloyed pearlitic malleable iron has also been determined at room temperature after prolonged exposure to temperatures of 1000, 1100 and 1200 F. The results of these tests are plotted in Fig 7. Lengthy high temperature exposures of the unalloyed pearlitic malleables caused softening. Hardness fell off rapidly during the first 25 hr at 1200 F, during the first 100 hr at 1100 F, and during the first 400 hr at 1000 F. Alloying delays the softening reaction and raises the final (minimum) hardness.

Impact

Investigators at the U. S. Naval Research Laboratory have employed a drop weight test to establish the nil ductility transition temperature and evaluate the shock toughness of several metals. They found good correlation between the drop weight test and the Charpy V-notch impact test. For pearlitic malleable irons made by reheating, air quenching, and tempering to a Brinell range of 160-190, the transition from a tough to a brittle failure occurs within the temperature range of −10 to −70 F. Higher silicon and phosphorous contents, and greater combined carbon in the matrix (i.e., stronger, harder irons) tend to raise transition temperature.

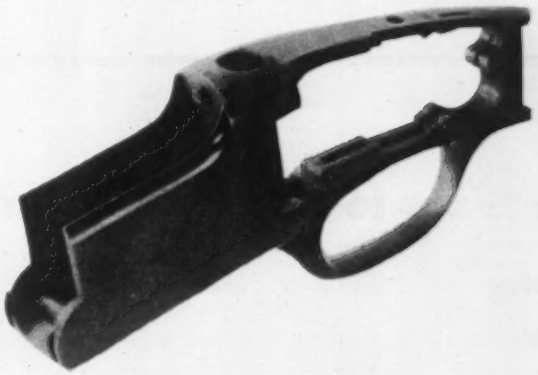
Other useful properties

Design versatility—The molten white irons from which pearlitic malleable castings are made have high fluidity, permitting complicated shapes to be cast in pearlitic malleable. Good surface finish and close dimensional tolerances are possible.

Freedom from casting stresses—Pearlitic malleable iron castings, like those of standard malleable iron, are produced by a manufacturing process in which heat treatment is both integral and essential. Any internal stresses that may have occurred as the casting solidified and cooled are removed by this treatment.

Machinability—Pearlitic malleable irons machine readily, but, because of their combined carbon content, somewhat less so than the standard malleables. The wide range of hardness and structure obtainable in pearlitic malleable irons makes it possible to adjust the degree of machinability deemed suitable for a particular requirement.

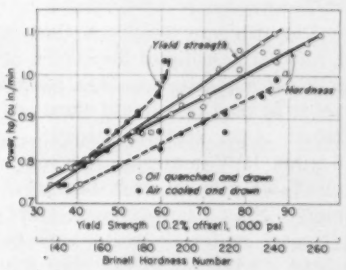
In the production of shotgun frames (Fig 8) machining was a major factor when the frames were originally hogged out of steel forgings. Conversion to pearlitic malleable castings eliminated much costly machining, not only through coring of the holes but also because of the superior machining qualities of the cast material. The savings in machining alone exceeded the cost of the casting. Moreover, an excellent machine finish was obtained.



8—*Shotgun frame was formerly hogged out of a steel forging. Making frame of pearlitic malleable resulted in reduction of machining costs greater than cost of new frame itself.*

Tests of pearlitic malleable iron, in which machinability was evaluated by drilling tests and expressed as the horsepower required to remove a cubic inch of material per minute, led to the conclusion that machinability bears some relation to yield strength and hardness, as shown in Fig 9.

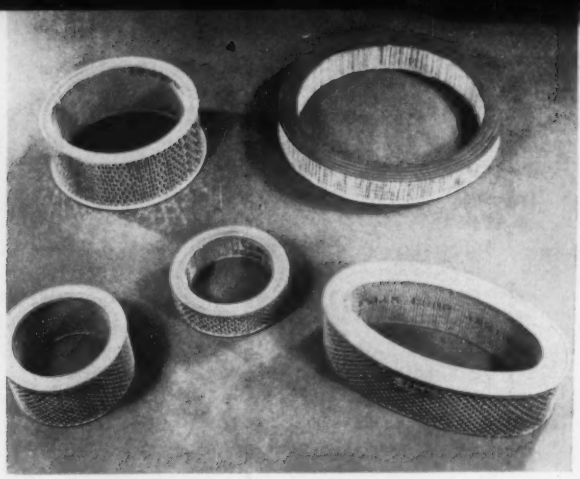
Wear resistance—Pearlitic malleable irons are generally preferred for applications in which wear resistance is a desirable property. Though not all pearlitic malleable irons have equal resistance to wear, the higher indentation hardness and stronger structure available through proper composition and heat treatment lead to excellent performance in such parts as gears, camshafts, chain links, and rolls. Hardened pearlitic malleable iron is often specified for gears.



9—*Hardness and yield strength are related to machinability.*

Molded Vinyl Plastisols

Five Problems They Have Solved



Auto air filter PROBLEM—Simplify assembly of Fram filter.
SOLUTION—Vinyl plastisol, molded-in-place against paper filter medium and fused on hot plate, forms embedment for paper, maintains structural integrity of filter shape, and forms gasket for attachment to motor mount. (See p 112 for how it's done). Replaces metal ring and precut gasket, both of which had to be adhered to end of filter element.
RESULT—35% reduction in production cost.

Four Ways to Fabricate Them

■ The versatility of flexible PVC (polyvinyl chloride), coupled with the ease of molding of a liquid casting material—this is the key attribute of vinyl plastisols. Because properties can be virtually the same as those obtainable in conventional PVC (see box on p 113), the design and production benefits inherent in plastisol forming techniques are the important things to understand. Typical benefits, as shown in the accompanying case histories, are reduction in tooling costs, replacements of several production steps, and forming of shapes uneconomical to form by other techniques.

Essentially, a vinyl plastisol is a fine-particle liquid dispersion of PVC in a plasticizer. The plastisol is formed in a liquid state and fused with heat to produce a flexible PVC material. Although plastisols usually cost somewhat more than conventional PVC (typical materials costs may be about 40-65¢ per lb for plastisols vs 27¢ per lb for an extrusion grade PVC), the cost of a part depends on the production method and volume, and may be lower than for parts formed by conventional techniques. Cycle time, including gel and fusion time, usually averages about 15 min., depending on mass of material.

In-place-molding

provides parts such as gaskets or seals permanently attached to other components. It often replaces several production steps.

The process—Surfaces against which the plastisol is to be applied must be either porous or prepared by roughing to provide a mechanical key with the plastisol. In many cases, the part against which the plastisol is applied serves as the mold, e.g., self-sealing nuts for sheet metal fastening, and crown closures for containers. In other cases, inexpensive molds must be fabricated.

The plastisol can be applied through a simple nozzle with little pressure. It is then heated to 300-400 F which causes gelling and fusing.

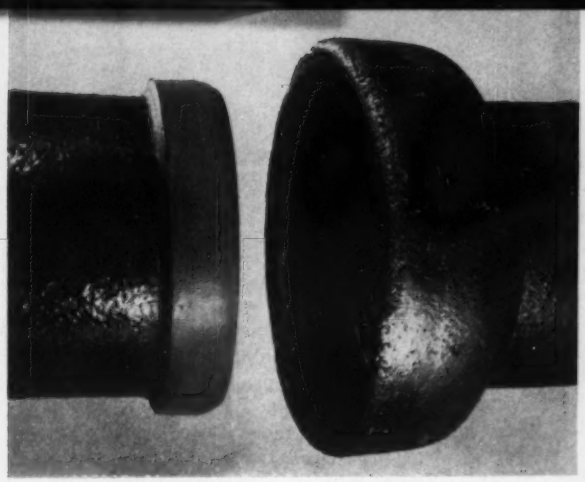
Design factors—Design limitations imposed by the process are those inherent in most casting operations. Quality of external detail is dependent on the finish of the mold.

Benefits of the process usually result from elimination of fabrication and assembly steps, such as those shown in the air filter application above. For example, when a plastisol is applied to a self-sealing nut for metal-metal fastening, it usually replaces some type of precut sealing washer. In the case of crown closure linings, it replaces precutting, stocking and adhering of composition cork linings. The plastisol is merely injected into the cap and fused.

Rotational casting

produces totally enclosed hollow parts at a high production rate. Detail finish is on the exterior of the part.

The process—A premeasured quantity of plastisol is poured into half of a two-part mold. The mold is closed, clamped and rotated in two planes. Simultane-



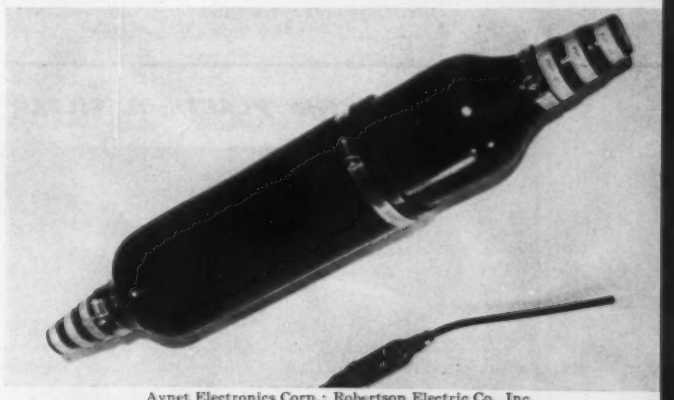
Vitrified clay pipe PROBLEM—Reduce pipe-laying time and labor; improve joint seal.
SOLUTION—Vinyl plastisol gasket applied to bell and spigot during production of pipe. During field connection, worker merely applies solvent cement to gasket, causing fusion when pipe is connected. Replaces calking operation previously required in the field.
RESULTS—Pipe laid two to three times faster; seal is watertight; pipe can be laid under water.

Akron Presform Mold Co.

Hobby horse bodies PROBLEM—Mold totally enclosed bodies with detailed surfaces at economical high production rates.
SOLUTION—Vinyl plastisol bodies rotationally cast at high production rate.
RESULTS—Excellent detail: virtually unlimited colorability; resilient vinyl provides safety feature; total enclosure precludes sharp edges; high production rate results in minimum costs.

Mesinger Mfg. Co.

Bicycle seat PROBLEM—Simplify assembly of bicycle seat.
SOLUTION—Rotationally cast vinyl plastisol seat cover, replacing stitched cover.
RESULTS—Low cost, simulated leather seat "envelope" formed rapidly and economically. Padding and springs added easily with no need for stitch-assembly.



Avnet Electronics Corp.; Robertson Electric Co., Inc.

Cable splice case PROBLEM—Case must be 1) dirt and moisture-tight, 2) resistant to weather and soil burial, 3) electrical insulating, 4) held to relatively close dimensions internally, 5) easy to close and reopen, and 6) simple to install.
SOLUTION—Dip-molded plastisol cases on conveyorized assembly line meet these requirements at minimum cost; replace metal cases both above and below ground.
RESULTS—Installation time in some cases reduced to one-fourth or one-half time previously required. Cases can be reopened easily for repairs.

ously, it is heated to about 500 F, producing a temperature of about 375 F on the interior. The hot mold surface gels and fuses the plastisol as it is dispersed evenly over the mold surface by centrifugal force. Rotation is halted and, after cooling, the mold is opened and the part removed.

Multiple-spindle machines, with gang molds on each spindle, provide high production rates. Equipment is expensive (about $20,000 and up) but volume production can provide low per-part costs. For example, often one man operates a 6-spindle machine, each spindle having a gang of 20 molds. Typical cycle may be about 15 min. Both batch and continuous-type machines are available.

Design factors—Shapes adaptable to rotational molding usually have a hollow center. Typical

spherical shapes are balls and artificial fruit; typical irregular shapes are hobby horses, bicycle seats, auto air ducts, and dolls.

In general, wall thickness should be 0.020 in. or greater. Variation in thickness can be produced either by 1) altering mold thickness to control intensity of heat in different sections, or 2) camming the equipment to produce eccentric rotational motion. Variation in wall thickness can generally range from 0.020 to 0.10 in.

As shown in the photo of the hobby horse bodies on p 111, intricate contours and sharp reentry angles can be produced with fine detail. Internal mold finish can provide a wide range of textures, including simulated stitching. Vinyl lacquers can be applied after molding to provide additional effects.

Slush molding

provides economical, small and large volume production of hollow shapes open at one end, with no parting line. Detail finish is on the exterior of the part.

The process—Although not as mechanized and precise as rotational casting, slush molding is somewhat similar. It differs in that 1) a one-piece mold open at one end is used, and 2) no centrifugal force is used. It can be conveyorized for large volume production.

The one-piece mold is preheated and filled with plastisol. The material next to the hot mold wall gels, and the residue is poured out. The gelled material is fused at about 375 F and, when cool, is stripped from the mold. The mold preheat temperature and dwell time before pouring off the residue determine the wall thickness of the part. In some cases, a double pour is used—the first in the cold mold to eliminate air pockets; the second after the mold has been brought to temperature

Design factors—Parts must have an open end since slush molded parts are stripped from a one-piece mold. The flexibility of plasticized vinyls allows parts with relatively drastic undercuts to be stripped. The one-piece mold also eliminates parting lines, reducing finishing operations.

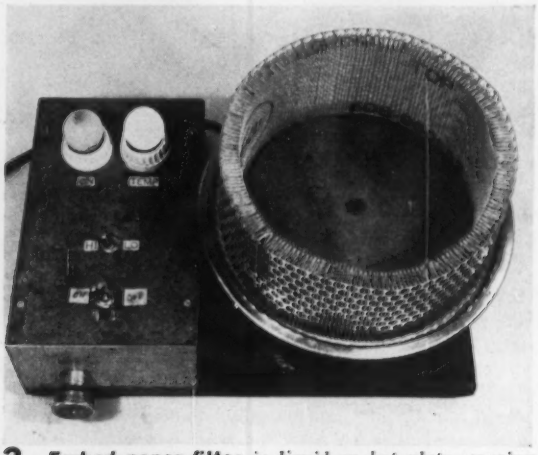
Dip molding

or mandrel dipping provides economical, small or large volume production of parts with internal detailed surfaces.

The process—A male mold is

HERE'S HOW THE PLASTISOL FILTER GASKET SHOWN ON P 110 IS APPLIED

1 ***Fill inexpensive mold*** *with liquid vinyl plastisol.*



2 ***Embed paper filter*** *in liquid on hot plate, causing gelling and fusion.*

3 ***Repeat process*** *on other end of filter.*

4 ***Strip mold*** *from fused vinyl; filter is now complete.*

preheated to about 375 F and dipped into the liquid plastisol. The plastisol adjacent to the mold gels, and after sufficient wall thickness has been built up the mandrel or mold is withdrawn from the plastisol. Withdrawal should be at a rate that does not exceed the rate at which the liquid residue drains from the gelled coating. The gelled coating is fused at a temperature of about 350 F. The part should then be stripped while it is still somewhat warm.

Design factors—Dip molding is usually best suited to production of slender, oblong shapes. Wall thickness is determined by temperature of the mold and time of immersion.

Generally, shoulders on the mold should be gradual to avoid air entrapment as the mold is immersed. Remember that the part must be stripped from the mold, and the degree of undercut permissible depends on the elongation of the plastisol.

Other techniques

Solid castings—Plastisols can be cast in inexpensive molds to produce solid shapes with no weight loss and exceptionally little shrinkage. Theoretically, there is no limit to the mass that can be cast, though heat transfer considerations during fusion may in some cases impose practical limits. Fusion will be complete when the material reaches a temperature of from 275 to 400 F. Fusion time, of course, depends on the mass, e.g., 5-min exposure to 350-375 F is generally required to fuse a 0.025-in. section. When casting a large volume, the plastisol should be formulated for maximum heat resistance.

Typical applications for solid castings include preformed gaskets and bushings, laboratory models, display plaques and flexible molds.

Coatings — Although plastisol coatings form a subject in themselves, they should be considered along with plastisol moldings and castings. (For additional information see "Vinyl Coatings for Metal Products," M/DE, Mar '57, p 130.) Coatings can be applied by dip, spray, spreader and die wiping techniques.

Although most plastisol coatings are applied to protect or decorate a product, in some cases the coating is applied to provide a base material with other inherent properties of vinyl, such as electrical insulation or abrasion resistance. Where a product must be made of a material other than vinyl, but some of vinyl's properties are desired on the surface, a plastisol coating may be the answer.

Properties of Vinyl Plastisols

A plastisol is a liquid dispersion of finely divided PVC (polyvinyl chloride) resin in a plasticizer. It is usually 100% solids with no volatiles; a plastisol whose volatile content exceeds 5% of the total weight is called an organosol.

When a plastisol is heated, the plasticizer solvates the resin particles and the mass gels. On continued application of heat the mass fuses to become a conventional thermoplastic PVC material.

In general, the wide range of properties that can be obtained by formulating injection or compression molded flexible PVC can also be obtained in fused plastisols. In some cases, range of properties is even wider, e.g., hardness. Because of this flexibility in formulating, few standards exist, and specific property data are relatively meaningless. However, the following general ranges are indicative of properties obtainable in plastisol parts (as well as molded flexible PVC).

Hardness—Shore A10 to D65.

Specific gravity—1.17 to 1.35.

Tensile strength — 500-2700 psi.

Elongation—150-600%.

Flexibility—Variable over wide range. Generally, flexibility decreases with increased hardness.

Resilience and set—Flexible PVC, though elastomeric, does not have the resilience of rubber. Its retraction is much more gradual. For example, standard compression set tests applicable to rubbers do not give meaningful results with PVC. PVC's recover from compressive deformation much more gradually than do rubbers.

Effects of heat—Conventional flexible PVC resists heat up to about 150 F. Specially formulated compounds can provide resistance to about 200 F for 2000-hr continuous exposure; 450 F for intermittent exposures of 2 hr or less. Because vinyls are thermoplastic, there is always some softening at these temperatures. This softening tendency can be minimized by proper formulating.

Effects of cold—Special formulation can provide flexibility at temperatures as low as –65 F. Such formulations usually have a hardness in the Shore A40-50 range, and a maximum service temperature of about 150 F.

Electrical properties—Dielectric strength is about 300-400 v per mil in thicknesses of ⅛ in. and over. Volume resistivity is about 10^{13}-10^{14} ohm-cm. Dielectric constant is about 3-11 at 60 cps.

Chemical resistance—PVC has outstanding resistance to most acids, alkalis, detergents, oils and some solvents. Resistance to solvents is somewhat marginal and excludes severe exposure to ketones and hydrocarbons. Optimum resistance to most corrosive agents is obtained at temperatures below 120 F. Resistance to many specific reagents can be improved by formulation.

Weatherability—A film 25 mils thick withstands a temperate climate for about three years. Degradation, when it occurs, is in the form of some color fading and stiffening.

Flammability—Slow burning. Self-extinguishing characteristics can be obtained by proper formulation

Acknowledgment

Information for this article was supplied by Chemical Products Corp., East Providence, R. I.

BRAZEABILITY OF COPPER-BASE ALLOYS

Name of Material	Nominal Composition, %	Condition	Res to Softening[a]	Res to Dist[a]	Res to Cracking[b]	Brazeability Rating	Remarks
Copper	Cu 99.9	Cast	Good	Good	Good	**Good**	—
	Cu 99, Sn 1	Cast	Good	Good	Good	**Good**	—
Copper, Tough Pitch	Cu 99.92 min., O 0.03	Wrought	Poor	Good	Good	**Good**	Avoid contact with reducing gases during brazing
Silicon Bronze	Cu 93, Zn 4.5, Fe 1, Si 1.5	Cast	Good	Fair	Good	**Good**	—
Cartridge Brass, 70%	Cu 70, Zn 30	Wrought	Poor	Fair	Good	**Good**	—
Low Leaded Brass	Cu 70, Zn 30, Pb 0.5	Wrought	Poor	Good	Good	**Good**	—
Naval Brass	Cu 60, Zn 39, Sn 1	Wrought	Poor	Good	Good	**Good**	—
Yellow Brass, High Strength	Cu 58, Fe 1.5, Zn bal	Cast	Good	Good	Good	**Good**	—
Phosphor Bronze, 5%	Cu 95, Sn 5.0, P 0.2	Wrought	Poor	Fair	Fair	**Fair**	Avoid stress during brazing. Heat uniformly
Silicon Bronze	Cu 94.5, Fe 1.5, Si 4	Cast	Good	Fair	Fair	**Fair**	Likely to crack if stressed during brazing
Tin Bronze	Cu 90, Sn 5, Ni 5	Cast	Good	Fair	Fair	**Fair**	Avoid stress during brazing
	Cu 89.5, Sn 6, Pb 0.5, Zn 4	Cast	Good	Fair	Fair	**Fair**	Avoid stress during brazing. Heat uniformly
	Cu 88, Sn 8, Zn 4	Cast	Good	Good	Fair	**Fair**	Avoid heating above 1380 F
	Cu 89, Sn 11	Cast	Good	Fair	Poor	**Poor**	Avoid brazing
	Cu 85, Sn 15	Cast	Good	Fair	Poor	**Poor**	Avoid brazing
Tin Bronze, High Leaded	Cu 80, Sn 4, Pb 16	Cast	Good	Good	Poor	**Poor**	Avoid brazing
	Cu 80, Sn 9, Pb 10	Cast	Good	Fair	Poor	**Poor**	Avoid brazing
Brass, Free-Cutting	Cu 62, Pb 3, Zn 35	Wrought	Poor	Poor	Poor	**Poor**	Avoid stress during brazing. Avoid quenching
Yellow Brass, High Strength	Cu 57, Zn 35, Fe 1.5, Mn 3, Al 3	Cast	Good	Poor	Poor	**Poor**	Susceptible to cracking if heated or cooled rapidly during brazing. Avoid brazing

[a]Determined primarily by form and physical properties of the alloy.
[b]Determined primarily by composition.

This table will help you decide . . .

Which Copper-Base Alloy for a Brazed Part?

by E. Belkin, *Materials Laboratories, Westinghouse Electric Corp.*

■ Copper-base alloys which are used for parts frequently joined by brazing are listed in the table. This table should aid those responsible for choosing materials and brazing techniques to select alloys which are the least likely to create materials problems.

The comments and ratings in the table are based on shop experience and metallurgical factors. It is these factors that are of concern in this article. No attempt has been made to deal with joint design, selection of fluxes or brazing filler metals, or techniques of brazing.

Although brazing difficulties sometimes stem from the particular brazing practice involved, there are many instances where characteristics of the base metals render them unsuitable for brazing, or at least are such that special precautions are necessary. If alloys having poor brazeability *must* be used, an understanding of the factors which may cause difficulty should minimize the problems. These same problems may exist to a lesser degree when using the more suitable alloys.

The difficulties most frequently encountered are tendencies to crack, soften or distort. Although these tendencies are interrelated, they are rated independently in the table and, for simplicity, will be discussed individually according to the predominant influences recognized by those brazing the alloys. The tendency to soften, for example, will be discussed in terms of the manner in which the alloy was strengthened—by varying alloy content, cold working or heat treating.

The 'unsuitable' alloys

The unsuitable alloys are rated in the table as "poor" or "fair," considering their overall suitability for brazing. "Poor" may be interpreted as referring to alloys that should not be brazed because of the strong likelihood of subsequent failure; "fair" as referring to alloys that must be brazed with caution.

For both these groups it is primarily the effect of chemical composition on the resistance to cracking (or embrittlement) which places these alloys in the unsuitable category. With respect to chemical composition, there are three elements and one compound which are the most likely to cause difficulties, although other elements can, under some circumstances, be considered harmful during brazing. But the four major constituents of concern are lead, tin, tellurium, and copper oxide. Copper oxide is included in this group because it exists in tough pitch copper, a material which is susceptible to hydrogen embrittlement if heated in a reducing atmosphere.

It is not correct, however, to assume that the likelihood of failure is determined only by the *amount* of an element present. The degree of segregation of an element and the manner of distribution, i.e., whether located in grain boundaries or randomly distributed, influence the possibility of failure. In addition, the amount and kind of other alloying elements that are present individually and collectively affect the chance of failure.

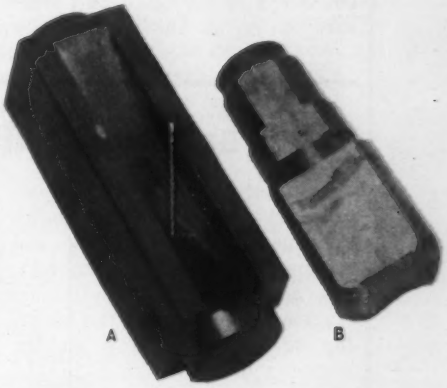
For brevity, let us generalize about the effect of just one of these elements—lead—which has recognizable limitations in any alloy. It has been found that when over 2% lead is present, it is best to avoid brazing. If brazing cannot be avoided, the following procedures must be carefully followed:

1. Heat slowly and uniformly.
2. Do not stress while at elevated temperature.
3. Cool slowly and uniformly.

Alloys with 2% (or less) lead are generally rated "fair" and the same procedure must be followed if failures are to be avoided.

Even with such precautions as these, failures do sometimes occur because of the presence of one or more of the four constituents. In such cases there is no alternative —other materials must be substituted. *(cont'd on next page)*

Altering the choice of materials *is often necessary to prevent cracking. This stem and disk (free-cutting brass) design has sharp corners and a large change in cross section, which intensified the problems associated with the lead-containing alloy. Substituting naval brass eliminated the cracking.*



Stress relieving *parts that may crack, as these have, is one way of avoiding difficulty. Parts A (copper-nickel-silicon) and B (chromium copper) had to be heated and cooled rapidly during brazing to maintain hardness. High residual stresses caused by machining (A) or sharp corners (B) were sufficient to cause cracking under thermal stress. Problem was solved by stress relieving 90 min at 1000 F before brazing, then air cooling rather than water quenching.*

Eliminating restraining clamping *may prevent cracking such as shown above. Two silver-tungsten contacts were brazed to the casting (manganese-bronze). Severe cracking resulted. When the stress level was reduced by eliminating the clamps during brazing, cracking no longer occurred.*

As a matter of precaution, when considering the brazing of alloys not listed in the table, the presence of any of the harmful elements should be recognized as a potential hazard, and advice should be sought before attempting to braze such alloys.

The 'suitable' alloys

Even for alloys that do not contain elements considered harmful, the operations of heating and cooling in brazing can cause serious adverse effects. Softening, cracking or distortion can occur, the severity depending on the geometry of the assembly (or the assembly and its components), on both the rate and uniformity of heating or cooling, on the maximum temperature attained during brazing, and on the length of time at brazing temperature.

Softening

Softening is a problem that occurs frequently because often the part to be brazed is made of an alloy that has been heat treated or cold worked. The decrease in hardness of a part and the distance from the joint over which softening occurs will depend on the brazing technique and the base materials. Excessive softening is probably the most frequent cause for rejection of parts (considering only brazing difficulties). Since parts are generally machined before brazing, the cost of these rejections is high.

Heat treatable alloys do not soften as drastically as cold worked alloys do at a given brazing temperature. Except for cast aluminum bronze alloy, heat treatable alloys achieve their hardness by being heated to a temperature in the range of 570-840 F after first being quenched from a higher temperature. Heating for brazing, which generally requires temperatures of 1250 F, results in some softening of the material. The higher the brazing temperature, and/or the longer the time, the greater the amount of softening. For example, experiments have shown that chromium copper will soften to a degree considered unserviceable, for some applications, when heated to 1380 F for 1 min.

Cold worked alloys soften severely during heating. The amount depends on the temperature and the amount of cold work to which the materials were subjected. The more severe the cold work, the greater the softening for the same temperature.

Some alloys, mainly cast alloys, do not soften significantly, and this is indicated in the table. These alloys owe their strength to alloy content, rather than cold working or heat treatment.

Softening measurements—Since softening is such a frequent problem, the problem of determining the degree of softening by means of a hardness measurement is also encountered frequently. Measuring the hardness of brazed parts is complicated by the necessity of determining the location at which hardness is to be measured as well as the minimum acceptable hardness value. Location of the hardness measurement is critical, since the loss in hardness is reduced as the distance from the joint increases. The choice of a minimum hardness value must be based on the ability of the part to satisfactorily perform in service. Care must be taken to avoid measuring hardness closer to the joint than necessary and thus rejecting pieces which can be used. Conversely, the location must be such that parts which have been softened below the minimum values are rejected.

Softening control — Three approaches, or combinations of them, are used to minimize the amount of softening during brazing:

1. Restrict heat to limited areas. Localized heating can be accomplished by heating only at the joint, but it is also possible to limit the heat-affected area by cooling the remainder of the part by using a heat sink or by partially immersing the part in water.

2. Cool rapidly after brazing. Parts may be subjected to an air blast or a water quench immediately after the brazing alloy solidifies.

3. Use a brazing alloy with the lowest melting range.

When employing either of the first two methods, remember that severe thermal gradients will be produced, and these may cause distortion or cracking. Thus, except for keeping the temperature, and time at temperature, at the lowest levels consistent with obtaining sound joints, methods for minimizing softening must be used with caution. The details of the brazing setup for heat treated alloys and cold worked alloys must many times be a compromise between accepting some amount of softening and risking the chance of cracking or severe distortion.

Distortion and cracking

Even those alloys which are free of harmful constituents can distort or crack upon heating or cooling. One cause is residual stresses introduced during casting, fabricating or machining. Upon heating, stress redistributes itself, causing the material to deform by an amount which depends on the magnitude of residual stress present, the shape of the part, the rate of heating, and the uniformity of heating.

Heating or cooling can induce thermal stress simply as a result of uneven expansion or contraction. Thermal stress increases in magnitude as the rate of heating or cooling is increased, and as the nonuniformity of heating or cooling is increased. These stresses add to the existing residual stresses, and if the total stress is sufficient, cracking or severe distortion may follow.

In some applications, fixtures are used to maintain proper alignment during brazing. To prevent cracking, the design, mass, and material of the fixture should be selected with consideration for the type of heating to be employed and the amount of restraint necessary to properly hold the parts during brazing.

Honeycomb

Part 1

- **How to Design Honeycomb Sandwich**
- **Materials for Sandwich Construction**

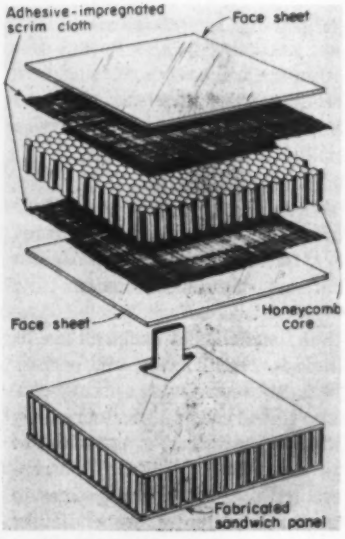
by Peter J. B. Stevens and Lloyd M. Polentz
Engineering Consultants, Los Angeles

■ The outstanding success of honeycomb sandwich structures in aircraft and missiles has aroused widespread interest in this material among designers and engineers in other industries.

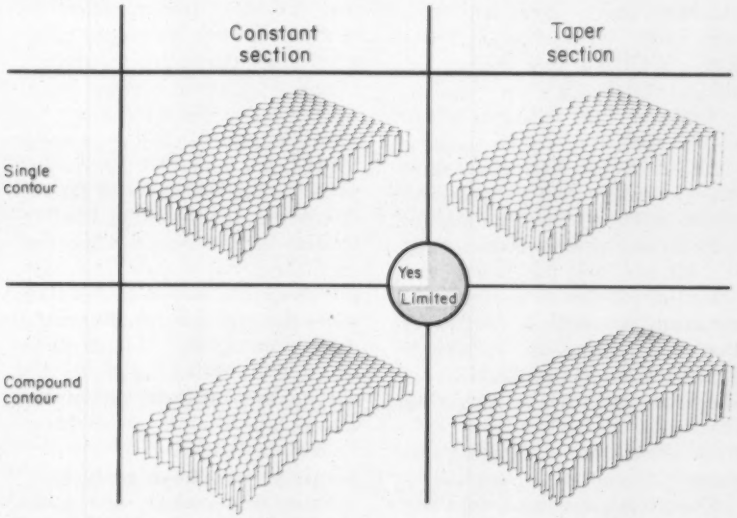
The purpose of this article is to group together the necessary basic formulas, design guides and procedures required for the application of honeycomb sandwich structures. The various materials and the details of applications are also given. The rules stated here will apply to structural parts in any industry and by following them, designers and engineers may take advantage of the high strength-weight ratio, low thermal conductivity, and vibration stability of this unique engineering material.

Honeycomb similar to other laminates: In concept, although not in appearance, the honeycomb sandwich is similar to any other laminated panel where layers of three or more materials are bonded together to produce a structure of greater strength than that of the sum of the individual layers. The honeycomb sandwich is usually made up of three such layers, with two outer sheets, or facings, bonded to a comparatively thick internal honeycomb core (see Fig 1). Honeycomb sandwiches may be designed either as flat panels of uniform thickness, or as structures with simple or compound curves (see Fig 2). This versatility of form gives the designer almost unlimited latitude in adapting the sandwich construction to his own design requirements.

High strength-to-weight ratio is probably the best known quality of the honeycomb sandwich.



1 ***What goes into*** *a honeycomb panel.* *(North American Aviation, Inc.)*



2 ***Contours possible*** *with honeycomb.* *(North American Aviation, Inc.)*

However, honeycomb panels have other superior qualities such as resistance to heat transfer and vibration, which are just as important as strength and weight in many applications. For example, resistance to heat flow and vibration both are ideal qualities for room partitions and exterior curtain walls of buildings. In the design of lightweight side panels for trucks and trailers, resistance to vibration plus high rigidity makes honeycomb panel construction an ideal design solution.

Honeycomb, as we know it today, developed out of paper honeycomb configurations which have been used for many years in sandwich applications such as core materials for plywood veneer doors and for strong, inexpensive, lightweight shipping containers.

Even though paper, plastics and wood are being used extensively today for core materials, metal cores are becoming increasingly important. The successful use of metal cores has been made possible by advances in bonding techniques. As a result the superior strength properties of metals are now being utilized to produce lighter and stronger honeycomb materials. The most common metallic honeycombs are fabricated from aluminum and stainless steel, although magnesium, titanium and beryllium have also been used in small quantities. In general, any metal that can be made into a foil and then welded, brazed, or adhesive bonded can be made into honeycomb and is, therefore, a potential metal for some future honeycomb application.

How to design honeycomb sandwiches

For specific examples see pp 120-121

In general: In a honeycomb sandwich, the facings are the prime load carrying members. The main function of the core is to provide an essentially continuous support and stabilization for the facings, which are under compression and/or tension when the panel is loaded. At the same time the core itself must withstand shear and compressive stresses resulting from the loading.

In an ideal honeycomb sandwich, as in the design of any structure, the individual parts should all fail at the same time under an excessive load. Such an ideal sandwich, however, would generally have extremely thin gage skins (unless the panel was designed for an edge loading application), since the tensile strength of most facing materials is high compared to the strength of the core material. Such skins could be easily punctured or torn under relatively low loading at concentrated points; consequently the skins on most panels are overdesigned, relative to the required structural strength of the panel. For edge loading—as opposed to flexural loading—applications of the skins must be heavier, since the core is doing relatively little work other than stabilizing the skins.

Honeycomb sandwich construction is almost always designed for flexural loading and therefore consists of thin, high density facings bonded to a relatively thick, low density honeycomb core. In such configurations, the advantages of honeycomb qualities are maximum and most apparent. For such honeycomb sandwiches the panel may be thought of as an I-beam; the panel facings represent the flanges and the core represents the web.

I-beams and honeycombs

When an I-beam is loaded there is a certain amount of bending in the beam. The upper flange is stressed in compression and the lower one in tension. Tensile and compressive loads are much lower in the web, and at the neutral axis they are zero. Under flexure, or bending, the web resists the maximum shear stresses at the neutral axis, and the shear stresses diminish to zero at the flanges.

Continuing the analogy between the I-beam and the honeycomb panel: when the panel is loaded, it experiences the same kind of bending as the I-beam. The facings carry the tensile and compressive loads caused by bending, while the core and bonding materials prevent the facings from buckling or wrinkling under the applied load. At the same time the core and bonding layers must resist the shear load.

Formulas for stress analysis

From this analogy, and actual test data, it has been found that the formulas used in calculating the stresses in I-beams can be used to determine the stresses developed in honeycomb panels. Considering a loaded sandwich panel with symmetrical facings (same materials of equal thickness) as a simply supported beam load, the stress in the facings may be calculated by means of the basic beam formula:

$$S = Mc/I$$

where S = stress in outer fiber, psi
M = moment, in-lb
c = distance (in.) from neutral axis to outermost fiber = $t/2$
I = moment of inertia of section, in.^{4}

For thin facings:

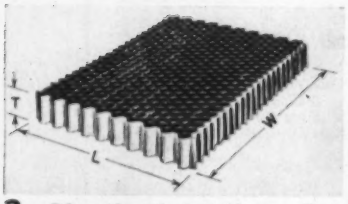
$$S = M/t_c t_f \text{ (approx)}$$

where t_c = thickness of core, in.
t_f = thickness of facings, in.

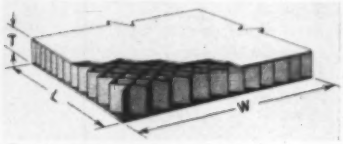
Similarly, the other relationships for deflection and shear stress of simply supported beams may be applied in honeycomb design.

Shapes of the cells

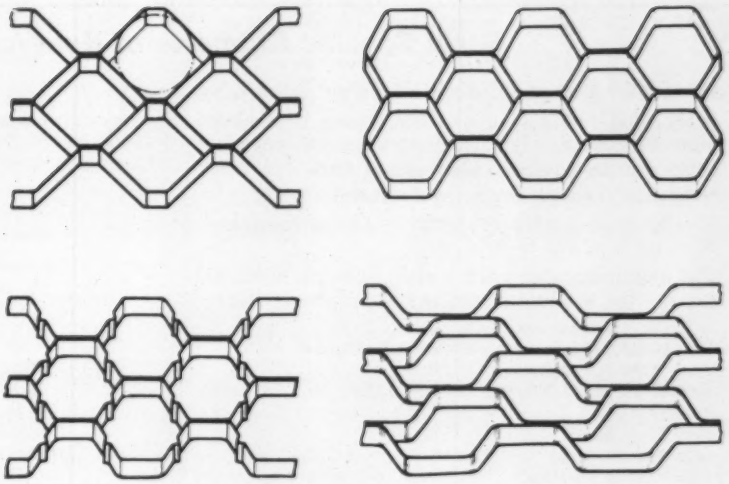
When the core is expanded to form hexagonal cells, it can be seen that each cell has two sides that are rigidly bonded to the sides of two adjacent cells. The other four sides of each cell are of single-layer thickness, and each is mutually shared with another cell. For this reason, the core has different strength properties in the three different directions represented by perpendicular lines to the three mutually perpendicular surfaces of the core, and is termed orthotropic.



3 Directional notations: *T is thickness or depth, L is ribbon or longitudinal direction, W is transverse direction (perpendicular to ribbons).* *(Hexcel, Inc.)*



4 Square-cell honeycomb.



5 Other honeycomb configurations. *(Aeronautical Research Institute of Sweden)*

These three directions shown in Fig 3 are defined as T for the thickness direction, L for the longitudinal, or ribbon, direction, and W for the transverse direction. When a panel containing honeycomb core is under a beam type of load, for example, the T direction is usually subjected to compressive stresses, while the L and W directions are subjected to shear stresses.

Another type of core configuration is shown in Fig 4. This core is formed with square cells and does not show the different directional properties in the L and W dimensions evidenced by the hexagonal core. The square cell honeycomb core is isotropic. Although the isotropic core is easier to analyze theoretically, it is more difficult to manufacture in equivalent strengths because of the smaller cell area coated with adhesive. For this reason the hexagonal cell is much more widely used.

Other types of cell configurations are employed to obtain special effects (see Fig 5) but these are only of general interest to the industrial designer.

Materials for honeycomb construction

Honeycomb core is fabricated from a number of base materials, including glass or asbestos-reinforced plastic, paper and aluminum. In addition to these three, core materials of titanium, stainless steel and other metals have been developed for unusual environmental applications; both stainless steel and titanium have high strength and corrosion resistance at very high temperatures. The development of titanium honeycomb core has been slow because of fabrication difficulties, but stainless honeycomb core is already specified in such advanced aircraft as the Convair B-58, where it is used, for example, in elevons and engine cowlings to resist extremely high temperatures.

Nonmetallic core materials

Glass — Glass fabric - plastic honeycomb core is made of glass cloth impregnated with resin, expanded to a honeycomb structure, cured, and then repeatedly coated with a polyester, phenolic, epoxy or silicone resin to desired thickness and strength. It is generally available in cell sizes ranging between 3/16 in. and 3/8 in. and in thicknesses from 0.060 in. to 18 in. Density for different cell sizes can be varied over a considerable range by changing the cloth thicknesses and the amount of dip coating; densities range from 2.5 to 10 lb per cu ft. Glass-plastic materials are normally formed in blocks or slices, although some manufacturers will pre-curve slices to specified contours at the request of users.

Paper—Paper honeycomb material is usually impregnated with a phenolic resin for strength and rigidity, as well as moisture resistance. Cell sizes vary between ⅓ in. and ½ in. Standard core thicknesses are available from ¼ in. to 6 in. Depending on paper core thickness and amount of impregnation, the densities range between 1.5 and 4.0 lb per cu ft. Because of the low thermal conductivity of impregnated paper, paper honeycomb core is often used in panels where low heat transfer is desired.

Metallic core materials

Aluminum — Aluminum honeycomb core materials are supplied in the expanded or unexpanded

(text continues on p 122)

Some Specific Examples of Honeycomb Design

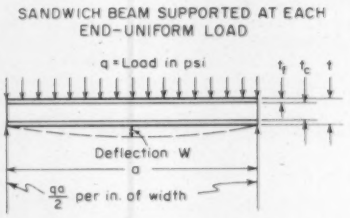
Design an aluminum sandwich cargo pallet 6 by 6 ft: This pallet is uniformly loaded to a maximum of 5000 lb. It is supported on two opposing edges by an edging which allows fork lift truck clearance. Design for a safety factor of 1.5.

$a = 72$ in.; $q = 5000/(72 \times 72) = 1.0$ psi (approx)
$M = qa^2/8 = 648$ in-lb/in. width

Use aluminum alloy with a yield strength of 40,000 psi for the sandwich facings:

$\sigma_f = M/t_c t_f$; $t_c t_f = 0.0243$
Use $t_f \geq 0.025$ in. for resistance to impact
$t_c = 1.00$ in. (approx)
Actual $\sigma_f = 25{,}900$ psi (40,000/25,900 = 1.54 safety factor)
$t = t_c + 2t_f = 1.05$ in.
$\tau_c = qa/(t + t_c) = 35.2$ psi
(Aluminum 3/8-3003-.002P honeycomb with a minimum τ_c of 63 psi is commercially available.)
Honeycomb safety factor = 63/35.2 = 1.75
$E_f = 10{,}000{,}000$ psi $\lambda_f = 0.91$
$D = (E_f t_f t_c t)/2\lambda_f = 144{,}000$
(Aluminum 3/8-3003-.002P with a minimum G_c = 12,500 psi is commercially available.)
$W = 5qa^4/386D + qa^2/8t_cG_c = 2.5$ in.

If this deflection is more than desired, increase t_c which will also increase the safety factor. For $t_c = 1.5$ in., $W = 1.15$ in. and weight of pallet, excluding edging, is computed as follows:



Maximum moment, $M = qa^2/8$
Maximum core shear stress and shear stress in bond, $\tau_c = qa/(t + t_c)$
Maximum facing stress, $S = M/t_c t_f$
Maximum panel deflection, $W = 5qa^4/384D + qa^2/8t_cG_c$

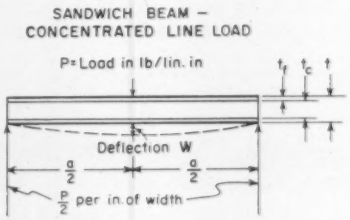
Honeycomb density = 3.0 lb/cu ft; facing density = 0.1 lb/cu in.
Honeycomb wt = 3.0 (1.5/12) = 0.375 lb/sq ft.
Facings wt = 2(0.1)(144) (0.025) = 0.72 lb/sq ft.
Adhesive wt = 0.05 lb/sq ft.
Panel wt = 0.375 + 0.72 + 0.05 = 1.145 lb/sq ft.
Total pallet wt, less edgings = 1.145 x 36 = 41.2 lb

Design an aluminum sandwich scaffold plank 14 in. wide to withstand a center load of 2 men (500 lb): This plank is supported over a span of 12 ft with a maximum deflection of 2 in. Design for a safety factor of 3 in the stress analysis. Since deflection will probably be the design criterion, the solution will start with this assumption.

$a = 144$ in.; $P = 500/14 = 35.7$ lb/in.

Using only the first term of the deflection formula (the second term is usually very small compared to the first) the solution is as follows:

$W = Pa^3/48D$; $D \geq 1{,}165{,}000$ for $W_{max} = 2.0$ in.
$D = E_f t_f t_c t/2\lambda_f$; $E_f = 10{,}000{,}000$ psi
$\lambda_f = 0.91$ $t_f t_c t \geq 0.212$ in.^{3}
Use $t_f = 0.032$ in., $t_c = 2.75$ in., $t = 2.314$ in., $t_f t_c t = 0.248$ in.^{3}
Actual $D = 1{,}360{,}000$
$W = Pa^3/48D + P_s/4t_cG_c$ (use $G_c = 12{,}500$ psi as in previous example)
$W = 1.67$ in.
Use $P = 3(37.5) = 112.5$ which will include safety factor.
$M = Pa/4 = 4050$ in-lb



Maximum moment, $M = Pa/4$
Maximum core shear stress $\tau_c = P/(t + t_c)$
Maximum facing stress, $S = M/t_c t_f$
Maximum panel deflection, $W = Pa^3/48D + Pa/4t_cG_c$

$\sigma_f = M/(t + t_c) = 46{,}000$ psi
Use an aluminum alloy with at least 46,000 psi yield strength.

$\tau_c = P/(t + t_c) = 20.2$ psi
(Al 3/8-3003-.002P honeycomb with $\tau_c = 63$ psi provides a safety factor of 3.1)

Design a section of a trailer floor to withstand a static load of 20,000 lb with a safety factor of 1.75: The floor section will be 10 × 10 ft and will be supported along each edge.

$a = 120$ in.; $b = 120$ in.; $q = 1.39$ psi; $\beta = 0.0479$
$\gamma = 0.420$; $\alpha_1 = 0.004$; $\alpha_2 = 1.84$

$M = \beta qa^2 = 957$ in-lb

Use an aluminum alloy for the facings with a yield strength of 40,000 psi.

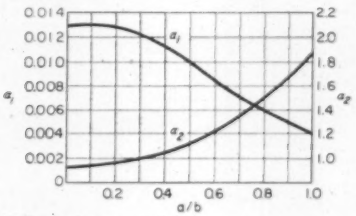
Working stress = 40,000/1.75 = 22,800 psi
$\sigma_f = M/t_c t_f$ $t_c t_f = 0.042$ in.^{2}
Use $t_f = 0.051$ in. to resist possible heavy impact loads.

Use $t_c = 1.00$ in.
Actual $\sigma_f = M/t_c t_f = 18{,}800$ psi
$\tau_c = 2\gamma qa/t + t_c = 66.6$ psi

For this design to maintain a safety factor of 1.75, Al-1/4-3003-.0025P honeycomb must be used (actual safety factor is 2.0). Although there is no requirement on deflection it should be checked.

$E_f = 10{,}000{,}000$ psi $\quad \lambda_f = 0.91$
$D = E_f t_f t_c t/2\lambda_f \quad G_c = 18{,}000$ psi
$W = \alpha_1 qa^4/D + (\alpha_1 \alpha_2 qa^2\pi^2)/t_c G_c = 3.82$ in.

This deflection is excessive and the trailer flooring should be redesigned. Maximum deflection should be 1/50-1/100 of the span.



Values for α_1 and α_2.

UNIFORM LOAD—EDGES SIMPLY SUPPORTED

Maximum moment, $M = \beta qa^2$
Maximum core shear stress, $\tau_c = 2\gamma qa/(t + t_c)$
Maximum panel deflection,
$W = \alpha_1 qa^4/D + (\alpha_1 \alpha_2 qa^2\pi^2)/t_c G_c$
Maximum facing stress, $S = M/t_c t_f$
Note: See graph at left for values of α_1, α_2, β, and γ

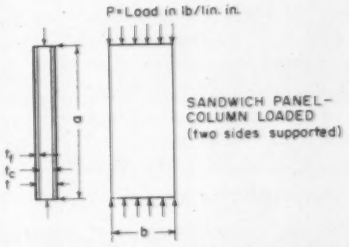
b/a	β		
	a_{max}	b_{max}	γ
1.0	0.0479	0.0479	0.420
1.2	0.0626	0.0501	0.455
1.4	0.0753	0.0506	0.478
1.6	0.0862	0.0493	0.491
1.8	0.0948	0.0479	0.499
2.0	0.1017	0.0464	0.503
3.0	0.1189	0.0404	0.505
4.0	0.1235	0.0384	0.502
5.0	0.1246	0.0375	0.501
∞	0.1250	0.0375	0.500

Design a panel to support a load applied to its edge: A stressed wall sandwich was previously designed and built to withstand a load of 300 lb/lin. in. Now another story is to be added on the existing structure, increasing the load to 550 lb/lin. in. $a = 120$ in.; $t_f = 0.025$; $t_c = 0.75$; $t = 0.8$

What safety factor may be expected under the new loading condition?

$\sigma_f = P/2t_f = 11{,}000$ psi
Since the aluminum alloy used has a yield strength of 28,000 psi, the facing stress safety factor is 2.54.
$D = E_f t_f t_c t/2\lambda_f = 82{,}400$
Critical load $P = \pi^2 D/[a^2 + (\pi^2 D)/(t_c G_c)]$

Since there is zero safety factor for critical load, this sandwich should be stiffened (probably by shortening a) prior to addition of another story.



Critical load, $P = \pi^2 D/(a^2 + \pi^2 D/t_c G_c)$
Facing stress, $S = P/2t_f$
To use these formulas it is essential that the load be applied equally to both facings. An edge insert in the panel, with the load applied to the insert, will allow this requirement to be met.

Design a trailer door to withstand a racking shear load of 80 lb/lin. in. of door edge. The door is to be 36 by 48 in. and should not exceed 0.5 in. in thickness. Design for a safety factor of 2.

$K = 5.35 + 4(b/a)^2 = 7.60$

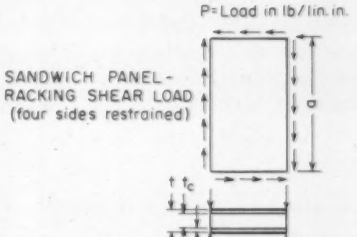
Trial 1: Use aluminum facings 0.020 in. thick with $t = 0.5$ in.

$\sigma_f = (K\pi^2 E_f t_c t)/(4\lambda_f b^2) = 11{,}600$ psi
Actual door stress $= 80/0.04 = 2000$ psi
(Design of Trial 1 has a safety factor of 5.8)

Trial 2: To resist roadstone damage it would be undesirable to decrease t below 0.020 in.

Honeycomb thickness may be reduced to $2/(5.8 \times 0.46) = 0.159$ in. (Use 0.1875 in.)

$\sigma_f = 47{,}300$ psi (safety factor of 2.3)

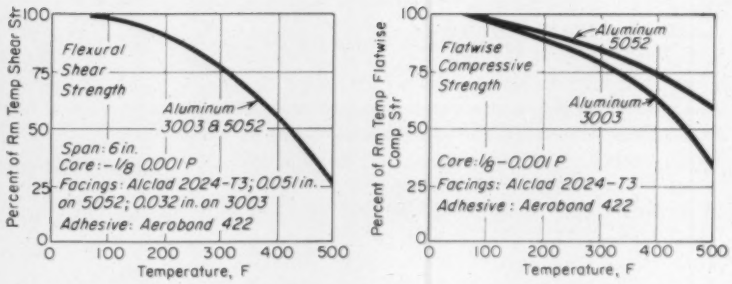


Critical facing stress, $S = (K\pi^2 E_f t_c t)/(4\lambda_f b^2)$
where $K = 5.35 + 4(b/a)^2$
For a single faced structure,
$S = K\pi^2 E_f/12\lambda_f\ (t_f/b)^2$

form in thicknesses from 0.060 in. to 18 in. or more if desired. By varying the cell size and the gage, honeycomb density can be closely controlled over a wide range. Aluminum core is available in cell sizes varying over a range of densities from 2 to 8 lb per cu ft and is usually supplied with perforations in the cell walls to permit gas and air flow during panel fabrication.

The most common aluminum alloy used in the production of honeycomb is 3003-H19, although 5052-H39 has gained wide acceptance among aircraft designers. Test results have shown that the 5052 alloy is approximately 20% stronger for the same density than the 3003 alloy both at room and elevated temperatures. Tests used in evaluating these honeycomb alloys are bare compression, flat-wise compression, flexure and plate shear at room temperature. At elevated temperatures (180, 240, 350 and 500 F) flat-wise compression, flexure and plate shear tests were also performed. Fig 6 shows the relative strengths of the honeycomb made from these two aluminum alloys.

Stainless steel honeycomb: The development of stainless steel honeycomb is a direct outgrowth of the aircraft and missile industries' need for high temperature materials to meet the demands of high speed flight. (Editor's note: This is also true of the superalloy and titanium honeycombs and will probably also be the major reason for the eventual development of beryllium honeycomb. Molybdenum honeycomb has an important potential as a structural material at temperatures as high as 2500 F.)



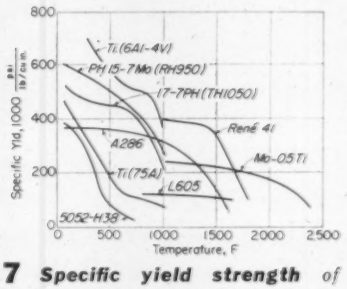
6 Mechanical properties *of aluminum honeycomb at elevated temperatures.* (Hexcel, Inc.)

Among the stainless steel honeycomb metals most used today are AISI 321 (annealed) and 17-7 PH. Various alloys such as AM 350, AM 355 and PH 15-7 Mo are also being investigated, and as other honeycomb-potential stainless steel alloys become available in foil form they will also probably be tested for specific types of applications. Fig 7 compares the properties of a group of these materials.

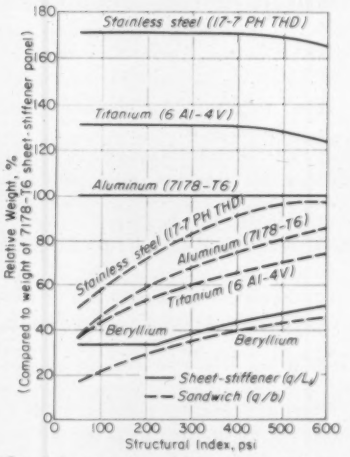
Titanium honeycomb—Fabricating techniques have been developed for titanium honeycomb, which has been produced from such titanium alloys as Ti-75, 6 Al-4 V, A110, and the DOD alloys. Titanium honeycomb is more or less competitive with stainless steel honeycomb as a high temperature structural sandwich core. Difficulty is still encountered in forming and machining titanium honeycomb, and the foil material from which the core is made is often not available in quantity. As with superalloys and stainless steels, the major reason for the existence of titanium honeycomb is its high strength-to-weight ratio (see Fig 8).

Facing materials

Thin, bondable material with high tensile or compressive strength-weight ratio is a potential facing material for honeycomb panels. The most common materials used for facings are fiberglass, aluminum, steel and wood. The sandwich facing can be finished with special exterior effects, such as decorative paints and enamels, or rough surfaces for anti-skid floor panels. In some cases, the skin may be embossed with a regular pattern to provide some special effect.



7 Specific yield strength *of various alloys vs temperature.* (Hexcel, Inc.)



8 Relative weight comparison *of sandwich and sheet stiffener construction.* (Rand Corp.)

Metals—Aluminum alloys such as 7075-T6, 2024-T3 and 2014-T6 are facing materials commonly used for structural, as well as nonstructural, applications in thicknesses from 0.010 to 0.064 in. Anodizing or coating with a protective resin can be done when

(continued on p 172)

MORE ENGINEERING & DESIGN

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How dangerous are plastics in fires?.....180

Low Cost Coatings for Metal Products

Low initial cost is often the most important factor when choosing a decorative and functional coating. Here is a survey of coating systems you should consider first where low cost is important. The coatings include:

- *Selected organic coatings*
- *Hot dip coatings*
- *Immersion coatings*
- *Vacuum metallized coatings*
- *Chemical conversion coatings*
- *Rust preventives*

by Robert J. Fabian, *Associate Editor, Materials in Design Engineering*

M/DE MANUAL NO. 168, MARCH, 1960

What do we mean by inexpensive?

Every coating may be considered inexpensive

Any article comparing the costs of engineering materials is bound to be controversial. This is especially true when comparing coating systems. Even if a coating costs a lot, if it is the only coating that will do the job then it must be considered as being the cheapest to use in the long run. Ceramic coatings and silicone paints, for example, are high in initial cost, yet they can do something no other coating can do—protect metals at high temperatures. Since they outlast any other coating they are often inexpensive in the long run.

Low initial cost is our criterion

In light of the above, what do we mean when we say that a coating is inexpensive? Well, for purposes of this article inexpensive will refer to those coatings that have a low materials cost in cents per square foot. This type of cost figure was decided upon after close study showed that it would be impossible to include the cost of all processing variables. However, in order to give a more meaningful cost picture we will try to indicate how much equipment is required, how much it costs, and how much handling of parts is required to apply the coatings. In this way a rough cost estimate can be made. Accurate estimates will vary with each application and can only be made after consultation with the materials and equipment suppliers.

Which coatings to include?

At the outset it should be stated that some arbitrary decisions were made as to which coatings to discuss. We have tried to include just those coatings that engineers commonly think of as being inexpensive. By this standard, such coatings would include:

Air drying organic coatings
Chemical conversion coatings
Metallic immersion coatings
Vacuum metallized coatings
Rust preventives

Rust preventives are only temporary and have to be removed when parts are ready for use. However, many rust preventives can be used for up to three years. In this manual they are treated equally with final coating systems that are an integral part of products throughout their life.

In addition to having low materials cost, the above coatings are *generally* applied easily with a relatively small amount of equipment and labor. The criterion of easy, low-cost application accounts for the exclusion in this manual of organic coatings that have to be baked and of inorganic coatings that have to be deposited by electrochemical means. The exclusion of such coatings is a debatable point. In some cases a thorough cost analysis might show that a coating system not included here is less expensive than one of the systems listed. For example, under certain conditions a particular metal may be applied more cheaply by barrel electroplating than by a non-electrical immersion treatment. Despite this anomaly, discussion will be confined to those application methods which are least expensive under *most* conditions.

How to use the manual

This manual is organized on two levels: a tabular summary of preliminary selection information, and a detailed text presentation. A quick summary of coating advantages and limitations is given in Table 1. This is followed by a comparison of important end-use properties, Table 2, and processing variables you should know, Table 3. Finally, a side-by-side comparison of the cost and uses of the various coatings is given in Table 4. Again, keep in mind that these cost figures are based on the as-applied materials cost of the coatings. Total cost includes many processing variables; we have tried, wherever possible, to indicate what these variables are.

In all cases the coatings described are applied to parts *after* fabrication. For a description of some of the cost factors involved in using precoated metals see "What About Precoated Metals?" on p 136.

Organic coatings

The end cost of an organic coating is determined by many complex factors. In addition to the basic cost of the resin itself, the user and/or the formulator must consider the type and amount of solvents and pigments needed, thickness of coating required for a given application, methods of application, and many other factors.

So it is very difficult to say which coatings are the cheapest. However, we can safely predict which coatings will be the least expensive *under most (not all) conditions.* Thus, under most conditions we can assume that a fast air drying coating will be cheaper than a baked coating. This assumption allows us to narrow the field down quite a bit. However, the user should realize that in almost all cases a baked coating will have better properties than an air drying coating. Nevertheless, low cost is our sole concern here.

Following is a rundown of the various air drying coatings that formulators recognize as being inexpensive. (For further details see "Organic Coatings for Metal Products," M/DE, Mar '59, p 113.) The applied cost of these materials varies roughly over a range of 0.5 to 2¢ per sq ft; more exact figures will be given wherever possible. Application costs depend on the application method and the amount of handling required. With few exceptions the coatings can be applied by just about any coating method, the most common being spraying, brushing and dipping. Application equipment costs can vary all the way from a few hundred dollars for a small scale spraying operation, on up to six figures for a completely automated setup.

One important item: the following analysis is intended only as an initial selection guide and your coating formulator should be consulted before making any final decisions.

Cellulosic

Nitrocellulose lacquers are one of the most popular group of fast air drying coatings in use today. The coatings are often used without a primer and are applied directly over metal. The metal should, of course, be clean and free of rust. If desired,

quality of the coatings can be upgraded by first giving the metal a paint bonding treatment. Since nitrocellulose coatings dry dust-free in just a few minutes they can be handled in a relatively short time and thus make possible rapid production schedules.

Clear nitrocellulose lacquers are widely used on metal novelty goods and art objects to prevent tarnishing. They are not recommended for outdoor use. However, some types of pigmented nitrocellulose lacquers, such as those used on automobile bodies, provide good service outdoors and have good color retention.

Coating properties can also be improved considerably by modifying nitrocellulose with alkyd, amino or natural resins, alkyd resins being the most popular (and most expensive) modifiers.

Cost of nitrocellulose lacquers depends on the end properties needed and the modifiers used. Some of the higher quality formulations run around 2.5¢ per sq ft; however, formulations costing about 1¢ per sq ft are obtainable for undemanding applications.

Alkyd

Coatings based on alkyd resins probably have more versatility than any other coating system. They run the gamut from low-cost fast-air-dry finishes to premium baked finishes. The most important types in terms of low cost are the long-oil alkyds, alkyds made from "pure" oils such as linseed or soya, the styrenated alkyds, and vinyl-toluene-modified alkyds.

Long-oil soya alkyds are popular for interior and exterior architectural enamels and marine finishes. One of the principal alkyds in this group is an air drying enamel which is ideal for marine use because of its combination of good color properties and resistance to water, salt spray and cleaning compounds.

Air drying long-oil alkyds are more widely used for maintenance purposes than any other coating. In addition to their good protective properties, they are low in cost (about 1.5¢ per sq ft) and can be used where baking is not practical. They do not have the properties of baked coatings, but are superior to oil paints and varnishes.

Styrenated alkyds are noted for their good color retention, toughness, and resistance to water and alkalis. In these respects they are superior to pure oil-modified alkyds; however, they are not as durable on exterior exposure. The coatings dry in a matter of minutes and do not usually have to be applied over a primer. Thus, they are quite suitable as fast-drying finishes on products such as toys and metal furniture. They can also be used on interior surfaces that must resist alkali cleaning solutions but are not subject to oil or grease contact. Cost of styrenated alkyd coatings is about 1.75¢ per sq ft.

TABLE 1—COATING ADVANTAGES AND LIMITATIONS: A QUICK SUMMARY

AIR DRY ORGANIC COATINGS	
Cellulosic	Fast air drying properties provide rapid production schedules. Coatings are tough, have good film strength. Available in wide range of colors and gloss. Excellent for decoration indoors. Appearance does not last as well as that of premium organic coatings; not recommended outdoors where long-term protection is needed
Non-Premium Alkyds	Combination of low cost and excellent range of colors. Particularly useful for indoor decorative use. Not recommended for long-term decoration and corrosion protection outdoors
Oleoresinous Varnish	Low cost; fast air drying properties
Bituminous (thin film)	Good corrosion protection for indoor applications (particularly on machined parts that have to be stored). Coatings have a natural black color, cannot be used for decorative applications
HOT DIP METAL COATINGS	
Zinc[a]	Provide excellent corrosion protection for indoor and outdoor service. Although not considered decorative coatings, appearance is sufficiently decorative for many consumer and industrial products
Lead[a]	Excellent resistance to atmospheric and chemical corrosion. Not recommended for decorative applications, but appearance satisfactory for many industrial uses
Tin[a]	Good resistance to corrosion, many chemicals
IMMERSION COATINGS	
Tin	Bright finish, modest corrosion resistance. Good lubrication properties on moving surfaces
Gold	Relatively low in cost (because of thinness). Excellent initial appearance, but tend to discolor and wear away with time and use
Silver	Good initial appearance, but not often used because of tendency to tarnish
Copper	Unique appearance, good lubrication properties
VACUUM METALLIZED COATINGS[b]	Provide bright, decorative metallic appearance. Well suited for large scale production. Lacquer primer and topcoat must be used to provide smooth appearance, protect against damage
CHEMICAL CONVERSION COATINGS	
Chromate Conversion Coatings[c]	Good corrosion protection at low cost. Available in many colors, although not as many as organic coatings
Phosphate Conversion Coatings[c]	Unpainted phosphate coatings provide good corrosion protection when treated with suitable oils, waxes or stains. Because of ability to carry oils they can also facilitate cold forming operations, improve wear resistance. They have little decorative value except when painted
Oxide and Other Coatings	Black coatings especially are noted for excellent appearance, nonreflectivity, corrosion protection. Also resist abrasion and chipping and, when oiled or waxed, reduce friction and galling
RUST PREVENTIVES	
Oil-Type	Excellent temporary corrosion protection for indoor and outdoor applications
Wax-Type	Good corrosion protection indoors (up to 3 years) and outdoors (up to 2 years). Many types have pleasing transparent appearance; hard, black types with high gloss are available
Corrosion Inhibitors	Displaces corrosion-producing fluids; protects metals during production, storage, shipment

[a] Refers to coatings that are applied after fabrication. For information on ready-to-use sheet see: "What About Precoated Metals?" on another page.
[b] Refers only to thin, decorative aluminum coatings.
[c] Coatings are also widely used to improve paint bonding. However, this article is only concerned with the end properties of the coating when used as is.

Oleoresinous varnish

An oleoresinous varnish is a mixture of natural or synthetic resins, a drying oil, and a solvent thinner. Types based on natural resins are especially noted for their combination of low cost (about 1¢ per sq ft), fast air drying properties, and protective ability. The least expensive types are based on natural resins; however, inexpensive types can be formulated from bottom products of synthetic resins.

Bituminous (thin film)

Although the materials themselves are inexpensive, bituminous coatings are usually applied in such heavy thicknesses that their cost in cents per square foot is relatively high. However, there are some types, such as the "thin film" coal tar or asphalt coatings, which can be applied in the relatively low thickness of 3 mils and cost less than 1¢ per sq ft. The coatings provide good corrosion protection where color is not too important and have a natural black color.

Thin-film asphalt coatings are widely used to protect machined parts in storage. The coatings can be easily removed with solvents when ready for use. Thin-film coal tar coatings, however, cannot be used for temporary protective applications because they are difficult to remove with solvents. On the other hand, this resistance makes coal tar-base coatings useful for protecting the bottoms of crude oil tanks and other products requiring resistance to solvent petroleum fractions. (For further details on the properties of these coatings see "Bituminous Coatings," M/DE, Aug '59, p 100.)

TABLE 2—IMPORTANT END-USE PROPERTIES[a]

Type ↓	Coating Composition, Structure	Metals That Can Be Coated	Appearance	
			Choice of Colors	Gloss and Luster
AIR DRY ORGANIC COATINGS				
Cellulosic	Hard, dried layer of organic and inorganic compounds	All	Unlimited	Unlimited
Non-Premium Alkyds	Same as above	All	Unlimited	Unlimited
Oleoresinous Varnish	Same as above	All	Unlimited but frequently used clear	Unlimited
Bituminous (thin film)	Same as above	All	Black only; not usually used for decoration	Not applicable
HOT DIP METAL COATINGS				
Zinc[c]	Although surface relatively pure, intermediate alloy layer is formed between surface and base metal	Ferrous metals	Silvery	Semi-bright
Lead[c]	Pure lead will not alloy with base metals. However, lead can be alloyed with other metals that will alloy with base metal	Ferrous metals	Gray	Dull
Tin[c]	Although surface is relatively pure tin, intermediate alloy layer is formed between surface and base metal	Ferrous metals	Silvery	Bright
IMMERSION COATINGS				
Tin	Discrete metal layer	Ferrous metals, copper and aluminum alloys	Silvery	Bright
Gold	Discrete metal layer	Most common metals	Yellow	Dull to bright
Silver	Discrete metal layer	Most metals except lead, zinc, aluminum and very active metals	Silver	Bright
Copper	Discrete metal layer	Steel, copper and aluminum alloys	Copper	Bright
VACUUM METALLIZED COATINGS[d]	Discrete metal layer	Most common metals (and nonmetallics)	Bright, silvery color. Various metallic colors can be simulated with colored lacquer topcoat	Bright

Notes on pp 128-129.

Hot dip metal coatings

Of all the types of coatings discussed in this manual, metallic coatings are probably the most expensive. Nevertheless, some metallic coatings, particularly those that are applied by hot dipping (and immersion) are relatively inexpensive when compared to premium organic coatings, porcelain enamels, and electrodeposited metals. It should be noted that hot dip coatings are not easily applied and application costs may be high. As mentioned earlier, electrodeposited coatings may be cheaper than hot dip coatings in some instances, but usually they are more expensive because of the relatively large amount of equipment and handling required.

Zinc

Properties and uses—Hot dipped (galvanized) zinc coatings have been popular for many years for protecting ferrous products because of their ideal combination of high corrosion protection and low cost. Their corrosion protection stems from three important factors: 1) zinc has a slower rate of corrosion than iron, 2) zinc corrosion products are white and nonstaining, and 3) zinc affords electrolytic protection to iron.

The amount of protection against corrosion depends largely upon coating weight—the heavier the coating the longer the life of the base metal. For example, a coating 1.8 mils thick (1 oz per sq ft) is estimated to have a life of 25 years in rural atmospheres, whereas, a 3.6 mil coating (2 oz per sq ft) will last 50 years. The life of zinc coatings may be five to ten times greater in rural atmospheres than in industrial atmospheres containing sulfur and acid gases. Nevertheless, the coatings are still popular for industrial use because of their low cost.

	Durability		Mechanical and Thermal Properties			
	Indoors[b]	Outdoors[b]	Adhesion	Abrasion Resistance	Impact Resistance	Heat Resistance
	Excellent	Not recommended for long term protection	Fair	Fair	Fair	Fair
	Excellent	Same as above	Fair	Fair	Fair	Fair
	Excellent	Same as above	Fair	Fair	Fair	Fair
	Excellent	Same as above	Fair	Fair	Fair	Fair
	Excellent	Very good	Excellent	Very good	Very good	Good
	Excellent	Very good	Very good	Very good	Very good	Good
	Excellent	Good	Excellent	Very good	Very good	Fair
	Excellent	Not recommended	Good	Very good	Good	Fair
	Excellent	Not recommended	Good	Fair	Good	Fair
	Good	Not recommended	Good	Fair	Good	Fair
	Excellent	Not recommended	Good	Fair	Good	Good
	Excellent	Good when protected with lacquer topcoat	Fair	Fair	Fair	Fair

(table continues on p 128)

American Zinc Inst.

***Large steel ducts** are given a bright, durable finish by hot dipping in a zinc bath.*

Hot dipping is particularly valuable for zinc coating parts that cannot conveniently be made of galvanized sheet. Thus it is quite popular for structural parts, castings, bolts, nuts, nails, pole-line hardware, heater and condenser coils, windlasses, and many other products.

How they are applied—Hot dip zinc coatings must be applied to absolutely clean metal. Consequently, surfaces are usually cleaned in a caustic or degreasing medium and then pickled. After rinsing, parts must be fluxed to promote bonding of the zinc coating. The coating itself is applied at 840 to 860 F. A zinc-iron alloy layer is formed between the base metal and coating. Immersion time depends on the thickness of coating desired, most coatings being applied in less than 1 min.

Cost factors—Materials cost of hot dip zinc coatings is relatively low. Assuming a 1.8-mil coating and a materials cost of 13¢ per lb, coating cost works out to 0.9¢ per sq ft. However, actual applied cost of the coatings will be somewhat higher than this figure because of the number of pretreatment steps, special equipment, heating, and technical know-how required. Because of these factors it is usually more economical for parts manufacturers to subcontract hot dipping work rather than attempt to do it themselves.

Lead

Properties and uses—Hot dip lead coatings provide many important advantages on ferrous metals. They are relatively inexpensive, provide very good protection against indoor and outdoor atmospheric corrosion, and can be used in contact with many chemicals such as sulfuric, hydrochloric, hydrofluoric, phosphoric and chromic acids. Their atmospheric corrosion resistance stems from the formation of a superficial oxide film which is relatively impervious to corrosion.

Because of their softness lead coatings can withstand severe deformation. Poor adhesion may be a problem since the bond is mechanical, but this problem can be minimized by adding alloying elements. Pinholes formed during application may be potential sources of corrosion but they can be eliminated by slight working or burnishing. Typical successful applications for the coatings are wire, pole-line hardware, nuts, bolts, washers, tanks, barrels, cans and air ducts.

How they are applied—Since pure lead will not alloy with ferrous metals, it is usually combined with an alloying agent such as tin which

alloys with iron, forming an interface between the base metal and the coating. A typical sequence of operations for coating small parts involves: solvent cleaning, electrocleaning, pickling, pre-dipping, fluxing, coating, and quenching.

Cost factors—A 1-mil thick coating of hot dip lead costs about 0.75¢ per sq ft, assuming a materials cost of 13¢ per lb. As with zinc coatings, the coatings are not readily applied, and application costs will be relatively high even though materials costs are low.

Tin

Properties and uses—Hot dip tin coatings can be applied to fabricated parts made of mild and alloy steels, cast iron, and copper and copper alloys to improve appearance and corrosion resistance. Like zinc, the coatings consist of two layers—a relatively pure outer layer and an intermediate alloy layer.

An invisible surface film of stannic oxide is formed during exposure which helps to retard, but does not completely prevent, corrosion. The coatings have good resistance to tarnishing and staining indoors, and in most rural, marine and industrial atmospheres. They also resist foods. Corrosion resistance in all cases can be markedly improved by increasing thickness and controlling porosity. Typical applications where they can be used are: milk cans, condenser and transformer cans, food and beverage containers, and various items of sanitary equipment such as cast iron mincing machines and grinders.

How they are applied—Steel products first have to be thoroughly cleaned and fluxed. They are then immersed in a preliminary tinning pot, followed by immersion in a second pot at lower temperature. Finally, the parts are withdrawn through palm oil or are dipped in a separate oil pot. Small parts are handled in one pot, centrifuged to remove excess tin, and then quenched or air cooled. Thickness of the coatings varies from 0.3 to 0.5 mil. The above treatments are typical and variations are used for cast iron and copper and copper alloy products.

Cost factors—Assuming a thickness of 0.4 mil, the cost of hot dip tin coatings will be roughly 1.6¢ per sq ft. As with other hot dip coatings, equipment and processing costs will be relatively high and should be carefully evaluated.

TABLE 2 (cont'd)—IMPORTANT END-USE PROPERTIES[a]

Type	Coating Composition, Structure	Metals That Can Be Coated	Appearance: Choice of Colors	Appearance: Gloss and Luster
CHEMICAL CONVERSION COATINGS				
Chromate Conversion Coatings[c]	Noncrystalline amorphous film made up of insoluble and soluble compounds	Silver, zinc (including coatings), and aluminum, copper and magnesium alloys	Wide range of colors obtainable, though not as many as in organic coatings	Very good; luster of base metal often adds to decorative appeal
Phosphate Conversion Coatings[c]	Inorganic layer of zinc phosphate, iron oxide or manganese phosphate. Except for amorphous phosphate coatings for aluminum, coatings have crystalline structure	Iron, steel, tin, cadmium, zinc, and aluminum and magnesium alloys	Cannot be colored; not usually used for decoration	Not applicable
Oxide and Other Coatings	Usually oxide of base metal. However, in some cases base metal does not enter into reaction	Iron, steel, cadmium, zinc, and aluminum alloys	Limited range of colors available (see text), most popular being black	Depends on coating; however, high gloss can be obtained
RUST PREVENTIVES				
Oil-Type	Soft to hard layer, depending on composition	Though all metals can be coated, mainly applied to ferrous and other metals unusually susceptible to corrosion	Transparent	Dull (soft) to bright (hard)
Wax-Type	Soft to firm waxy layer, depending on composition	Same as above	Transparent, brown, amber	Same as above
Corrosion Inhibitors	Very thin layer of complex chemical compounds	Usually ferrous metals	None	None

[a]Relative comparisons apply only to those coatings shown in the table. For example, even though an alkyd coating might have excellent abrasion resistance compared to other organic coatings, its abrasion resistance may not compare favorably with that of some metallic coatings.
[b]Comments apply to coatings that are not severely handled or exposed to corrosive chemicals.
[c]Refers to coatings that are applied after fabrication. For information on ready-to-use sheet see: "What About Precoated Metals?" on another page.

Immersion coatings

Except for electroless nickel, immersion coatings are generally less expensive and can be applied more quickly than equivalent coatings applied by electrodeposition. As a rule the thickness of immersion coatings is limited, since plating stops when the base metal is covered. However, in some cases further plating can be produced by placing the base metal in contact with a dissimilar metal and inducing an electric current.

Following is a summary of the most important types of coatings.

Tin

Properties and uses—A variety of tin immersion processes can be used to improve the decorative and/or functional properties of many common metals. Principal advantages of the processes are: 1) they are easy to use and require less skill than hot dipping or electroplating, 2) they are economical and do not require electrical or other expensive equipment, and 3) they deposit very thin, uniform coatings so that a little tin goes a long way.

Tin immersion coatings can be applied to metals such as copper, brass, bronze, aluminum and steel. The coatings have a bright appearance and fair corrosion resistance, and thus are popular for finishing small articles such as safety pins, thimbles and buckles. They are also applied to copper tubing to prevent discoloration from water, and are frequently applied to aluminum engine pistons to provide lubrication during break-in periods.

How they are applied—Most tin immersion processes are empirical and many modifications are used depending on the base metal being treated. A typical treatment for copper tubing involves cleaning, rinsing, immersion for 1 hr in tin salt solution, hot rinsing and fast drying. In comparison a typical treatment for aluminum requires two more steps but is done in much less time. After cleaning and rinsing, parts are given a nitric acid dip, rinsed again and then immersed in a potassium stannate solution for 3 to 4 min at 120 F to deposit 0.1

	Durability		Mechanical and Thermal Properties			
	Indoors[b]	Outdoors[b]	Adhesion	Abrasion Resistance	Impact Resistance	Heat Resistance
	Excellent	Generally provides better corrosion resistance than phosphate coatings	Very good	Fair	Very good	Good
	Excellent	Not generally used alone for corrosion protection. However, provide good corrosion protection, especially on ferrous surfaces when treated with oils, waxes or stains	Very good	Excellent	Very good	Good
	Excellent	Some types can moderately improve outdoor corrosion resistance	Very good	Fair to excellent	Very good	Good
	Excellent	Good	Good[f]	Fair	Very good	Fair
	Excellent	Good	Good[f]	Fair	Very good	Fair
	Excellent	Fair	—	—	—	—

[d]Refers only to thin, decorative aluminum coatings.
[e]Coating is also widely used to improve paint bonding. However, this article is only concerned with the end properties of the coating when used as is.
[f]Soft types can be wiped off, but hard types have relatively good adhesion. Degree of adhesion is also influenced by porosity of base metal.

mil of tin. Parts are then given cold and hot water rinses.

Cost factors—The materials cost of tin immersion coatings depends on the thickness used. Up to 2 mils have been deposited for heavy duty industrial applications. However, a thickness of 0.015 mil is common for decorative uses. Cost of metal alone in this thickness would be about 0.06¢ per sq ft. Cost of the chemicals would be double this amount.

Gold

Because of their extreme thinness, gold immersion coatings are relatively inexpensive. They have a bright, attractive appearance which, while not very durable, can be protected with a clear lacquer finish. The coatings are principally used in decorative applications such as costume jewelry, trophies, automotive trim, and many novelty goods. And because of their good conductivity they are also useful in electrical applications such as printed circuits, transistors and connectors.

How they are applied—One of the principal immersion treatments available deposits gold by ionic displacement and contains no free cyanide. Gold can be simply applied by this treatment to most common metals after they have been given a conventional cleaning treatment. The depositing reaction is self-regulating; the thickness deposited depends on the base metal and the reaction stops in a few minutes when the surface is completely coated.

Cost factors—Gold immersion coatings can only be considered inexpensive when used in very low thicknesses—on the order of 0.001 mil (a millionth of an inch). In this thickness it costs about 6¢ per sq ft.

Silver

Despite their low cost, silver immersion coatings are not too popular. Because of their poor tarnish resistance and inability to withstand abuse, their use is restricted to very cheap decorative applications and minor electronic parts. They can be applied to most base metals except lead, zinc, aluminum and very active metals. They perform best on copper, nickel and steel.

Usually just a flash of silver—about 0.01 mil—is deposited; however, 0.03 mil can be deposited in some cases. Application time depends on solution concentration, 3 min being about average. Assuming a thickness of 0.01 mil and metal cost of 92¢ per troy oz, cost of the coatings works out to about 0.6¢ per sq ft.

Copper

In general, electroless copper coatings are cheaper to apply than equivalent electroplates. Most of the applications of the coatings today are for printed circuits. Although they do not actually have much decorative appeal, they are nevertheless used for some inexpensive, decorative metal hardware such as casket parts. Because of their good lubrication properties they are also used on steel wire in die forming operations.

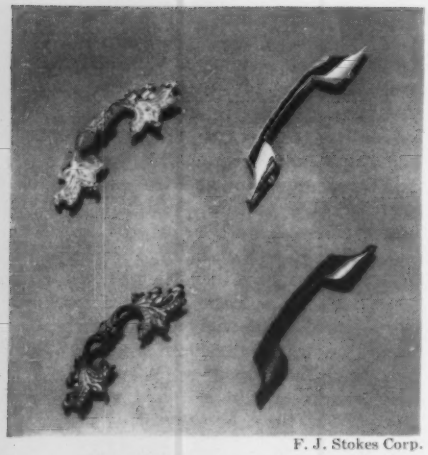
Electroless copper coatings are usually used in thicknesses of 0.1 to 1 mil. In addition to steel they can also be applied over brass, and on aluminum under special conditions. Normal cleaning cycles required are the same as for copper electroplating. Processing time is slower than for electroplating and depends on the thickness required.

Cost of the coatings is a fraction of 1¢ per sq ft. It has been estimated that the coatings can be applied on a small scale with equipment costing about $100. Similarly, equipment costs for a full-scale automated setup are roughly estimated to be $10,000.

Vacuum metallized coatings

Properties and uses—Vacuum metallized coatings can be applied to almost all common metals and nonmetallic materials to improve their appearance. Aside from nonmetallics, they are usually applied to low cost metals such as steel and zinc. The use of thick cadmium coatings has recenely been extended to heavy duty functional applications. However, these coatings are relatively expensive, and our main concern here is cheap, decorative aluminum coatings.

Such vacuum metallized coatings consist of a thin, bright aluminum layer with excellent decorative properties. Thickness of the coating



F. J. Stokes Corp.

Zinc die-cast drawer pulls *as they appear before and after metallizing.*

ranges from 0.003 to 0.005 mil. Actually, the metal is deposited slowly compared to electroplating, but the process is economical since the coatings are thin and many parts can be treated simultaneously.

Because of their thinness the coatings tend to reproduce any imperfections in the base metal. Thus, surfaces must usually be leveled with an organic coating before metallizing. Furthermore, these thin coatings must be protected with a clear organic coating to resist corrosion, abrasion and handling. Metallic colors other than aluminum can be simulated by using a colored top lacquer or by dyeing the top lacquer after application.

Aluminum-coated steel and zinc are popular for such items as hardware, costume jewelry, optical reflectors, instrument parts, appliance trim and automotive interior hardware.

How they are applied—During vacuum metallizing the metal to be evaporated is brought into contact with a hot tungsten, molybdenum or platinum filament (or it may be electrically heated in a refractory crucible) in a vacuum of at least 10^{-4} mm Hg. The metal evaporates quickly (however, deposition of heavy cadmium coats takes 15 to 30 min) and condenses on a straight line from the filament. Parts requiring coating on both sides must be rotated. Coating of deep grooves, undercuts and interior surfaces is not practical.

Cost factors—The cost of the aluminum coating material is a small

TABLE 3—PROCESSING VARIABLES

Type ↓	Application Methods, Equipment	Pretreatment	Approx No. of Processing Steps[b]	Time Before Coated Part Can Be Handled
AIR DRY ORGANIC COATINGS				
Cellulosic	Brushing, spraying, dipping, flow coating; equipment depends on method used	Surfaces free of dirt, oil, grease if high quality needed. Min pretreatment: cleaning, rinsing, drying	4+	15 min
Non-Premium Alkyds	Same as above	Same as above	4+	30 Min
Oleoresinous Varnish	Same as above	Same as above	4+	—
Bituminous	Same as above	Same as above	4+	—
HOT DIP METAL COATINGS				
Zinc[c]	Dipping, several tanks req'd	Cleaning, pickling, fluxing	6+	Parts are at 800-900 F when removed; can be handled as soon as cool
Lead[c]	Same as above	Cleaning, pickling, fluxing	11	Parts are at 640-680 F whenremoved and can be handled as soon as they have cooled
Tin[c]	Same as above	Cleaning, pickling, fluxing	6+	Parts are at 570-625 F when removed and can be handled as soon as they have cooled
IMMERSION COATINGS				
Tin	Dipping, small no. of tanks req'd	Depends on base metal; cleaning usually sufficient but acid dip may be req'd	4+	Several minutes
Gold	Same as above	Cleaning, rinsing	3+	Several minutes
Silver	Same as above	Cleaning, rinsing	3+	Several minutes
Copper	Same as above	Cleaning, rinsing	3+	Several minutes
VACUUM METALLIZED COATINGS[d]	Vapor deposition; principal item of equipment is vacuum tank	Must usually be applied over smooth lacquer film	3+	Depends on hardening time of lacquer topcoat
CHEMICAL CONVERSION COATINGS				
Chromate Conversion Coatings	Dipping; no. of tanks req'd depends on type of coating	Parts must be freed of all contaminants; min steps req'd are alkaline cleaning, rinsing	4	Several minutes; depends on temp of final rinse
Phosphate Conversion Coatings	Dipping usually satisfactory for most parts; no. of tanks req'd depends on type of coating. Very large parts can be sprayed	Parts must be free of all contaminants; min steps req'd are cleaning, rinsing	5+	Same as above
Oxide and Other Coatings	Dipping; no. of tanks depends on type of coating	Same as above	5+	Variable, depends on temp of final rinse or nature of rust preventive treatment
RUST PREVENTIVES				
Oil-Type	Brushing, spraying, dripping, flushing	Cleaning	3+	Hard types can be handled as soon as solvents have evaporated. Care req'd with soft types to prevent removal of coating
Wax-Type	Same as above	Cleaning	3+	Same as above
Corrosion Inhibitors	Brushing, spraying, dipping	Many surfaces can be treated directly	1+	Several minutes

[a] Relative comparisons apply only to those coatings shown in the table.
[b] Including pretreatment steps.
[c] Refers to coatings that are applied after fabrication. For information on ready-to-use sheet see: "What About Precoated Metals?" on another page.

YOU SHOULD KNOW[d]

	Average Thickness, mils	Coating Uniformity	Ability to be Applied in Blind Areas	Suitability for Large Parts	Suitability for Small Parts in Large Quantities
	1	Excellent	Depends on application method. Blind areas difficult to reach by brushing or spraying, but can be dipped	Size is no limitation	Very good provided parts do not contact each other during application
	1.5	Excellent	Same as above	Same as above	Same as above
	1	Excellent	Same as above	Same as above	Same as above
	3	Excellent	Same as above	Same as above	Same as above
	0.8-2	Excellent	Excellent	Usually for small and medium size parts. Large parts usually made from precoated sheet	Excellent
	0.5-2	Fair; precautions req'd to prevent pinholing	Excellent	Same as above	Excellent
	0.4	Excellent	Excellent	Large parts are usually made from precoated sheet	Excellent
	0.015	Excellent	Excellent	Not recommended	Excellent
	0.001+	Excellent	Excellent	Not recommended	Excellent
	0.01	Excellent	Excellent	Not recommended	Excellent
	0.1-1	Excellent	Excellent	Not recommended	Excellent
	0.005	Excellent	Poor	Poor	Excellent
	0.01-0.05 mil of metal may be dissolved; film depth is about 0.02 mil	Excellent	Excellent	Excellent; limited only by size of processing tanks	Excellent
	70-5000 mg/sq ft[e]	Excellent	Excellent	Excellent	Excellent
	0.04-0.2	Excellent	Excellent	Excellent; limited only by size of processing tanks	Excellent
	1+	Hard types have excellent uniformity. Soft types require special care to prevent removal	Excellent	Excellent	Excellent
	2+	Same as above	Excellent	Excellent	Excellent
	Extremely thin molecular film	Excellent	Excellent	Excellent	Excellent

[d]Refers only to thin, decorative aluminum coatings.
[e]Conventional thickness measurements are not normally used with phosphate coatings; rather, coverage is measured by coating weight in mg/sq ft.

part of total materials cost. Actually, the organic undercoat and topcoat cost more than the metal deposited, and total materials cost of the complete coating system is roughly 1¢ per sq ft. Equipment cost is relatively high as, in addition to the vacuum chamber itself, application equipment is needed for the organic coatings. Although less expensive vacuum chambers are available, the cost of an average size chamber (30 in.) is about $9000, including pump and rotating fixtures.

Chromate conversion coatings

General properties

Chromate conversion coatings are low in cost and have achieved rapid popularity because of their ability to improve the appearance of nonferrous metals and protect them against corrosion. Although the coatings are widely used to improve the appearance and properties of metal coatings, this manual is concerned only with chromate coatings used over solid metal parts as a complete finishing system. Chromate coatings are also quite popular as a base for organic finishes, but this property too is outside the scope of this manual.

Composition—Essentially, the coatings consist of insoluble, nonmetallic, trivalent chromium compounds and some soluble hexavalent chromium compounds. Unlike most phosphate conversion coatings, chromate types are noncrystalline and amorphous.

Corrosion resistance—The protection afforded by chromate coatings is twofold. First, the nonporous nature of the film acts as a barrier to prevent moisture from reaching the metal. Second, if the coating should be scratched, the soluble portion of the chromate film continues to exert self-healing action to retard corrosion of the metal.

The protective value of the coatings depends on a number of factors such as: type, thickness and hardness of the coating, surface characteristics, purity and thickness of

the basis metal, method of application, and service environment.

Appearance — Chromate coatings are generally less than 0.02 mil in thickness. Two types of thin bright films can be obtained: yellow iridescent and clear. Clear coatings are not as durable as yellow or olive drab coatings and, consequently, are often protected with a clear lacquer. Because of their brilliant appearance, clear coatings have been used to simulate nickel-chromium electroplates.

Heavier, matte coatings in yellow, bronze, black, brown and olive drab (the most durable and protective) colors can also be obtained. Because of their absorptivity, yellow and olive drab coatings can be converted to other colors by immersion in acidified organic dyes. These colors include red, orange, green, blue and violet. The range of colors obtainable is not as great as with dyed anodic coatings, and the colors are not as attractive or as fast to light. For this reason the colors are only used for identification purposes or for indoor applications.

Coatings for zinc

Properties—Under ordinary conditions zinc has a tendency to develop a grayish color which detracts from its appearance. Also, when exposed to moisture, it may develop corrosion products. Chromate coatings are particularly effective in inhibiting this type of corrosion and for this reason are more widely applied to zinc (and to cadmium) than to other metals.

How they are applied—Since die castings are relatively dirty, they have to be cleaned first, usually in an alkaline cleanser. Then the parts are rinsed, dipped in chromate, rinsed again, and dried.

Cost factors—The as-applied cost of chromate coatings on zinc surfaces ranges from 0.05 to 0.4¢ per sq ft, exclusive of handling and equipment costs. The cost for a small scale operation is relatively low; the equipment for treating die castings costs about $500 per 100 gal of solution capacity.

By comparison, the approximate equipment cost for a large scale, fully automated setup would be about $20,000 per 500 gal of solution capacity. This cost applies to equipment for treating solid zinc parts as well as all other solid nonferrous metals.

Coatings for aluminum

Properties—Chromate conversion coatings on aluminum have replaced anodizing in many applications where low cost, good corrosion resistance, low electrical resistance, and flexibility (and good paint bonding) are required. Chromate coatings are much thinner (about 0.01 mil) than anodic coatings, and color varies from clear to dark as thickness increases. They can be used on all aluminum alloys, including work hardenable and heat treatable alloys in rolled, drawn, extruded and cast forms.

Chromate coatings have very low resistance to electric current and can be classed as conductors rather than dielectrics. Resistance values vary from 2500 to 50,000 microhms, depending on coating composition and operating conditions. Thus, the coatings can be welded, and it is possible to weld chromated sheets right from stock without preliminary cleaning.

How they are applied—Chromate treatment of aluminum alloys is essentially the same as for solid zinc. Following alkaline cleaning and rinsing, parts are chromate treated, rinsed and dried. One additional dip and rinse are required for dyeing.

The coatings are usually applied by dipping, but spraying, brushing or flow coating can also be used. Brush or flow coat application is used on assemblies too large for tank immersion, or for touching up. Optimum immersion time for a clear treatment is 10 to 30 sec; for yellow coatings about 2 min.

Cost factors—The cost of clear coatings on aluminum varies from 0.01 to 0.05¢ per sq ft. Colored coatings run a little higher—from 0.05 to 0.3¢ per sq ft for yellow or brown coatings. As with coatings for zinc, the minimum equipment cost for a small scale operation using hand labor is about $500 per 100 gal of chromate solution capacity.

Coatings for magnesium

Properties—A considerable number of chemical conversion coatings are available for improving the corrosion resistance, appearance, and paint bonding properties of magnesium alloys. Most of these coatings consist of complex chromic and chromate compounds. Some of the treatments (notably Dow Nos. 1 and 10) are considered suppliers treatments and are applied to cast and wrought products before shipment.

Following is an analysis of a few of the important types. Many others are available and information is readily obtainable from metal producers and coating suppliers.

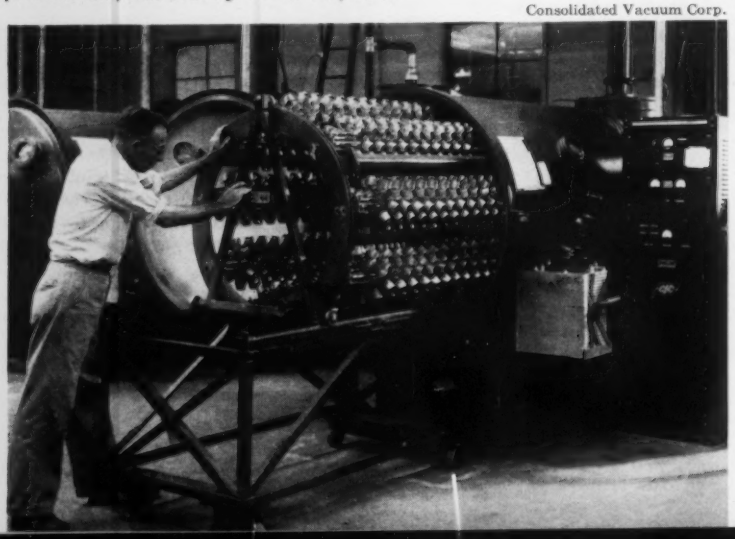
Dow No. 1 chrome pickle is probably the most widely used general purpose treatment. The coating can be applied to practically all magnesium alloys and is frequently used for temporary protection during shipment and storage. Since the etching action of the chrome pickle removes about 0.6 mil of metal per surface it is not recommended for machined surfaces unless tolerances permit or allowances are made.

Dow No. 7 dichromate treatment provides excellent corrosion protection and good paint-base characteristics to all magnesium alloys except M1A and the newer rare earth alloys. Color of the coatings varies from light to dark brown, depending on the alloy. The coatings can be applied after machining, since no appreciable dimensional changes are produced during treatment.

Dow No. 10 treatment is essen-

***Small parts** to be vacuum metallized are mounted on rotating brackets to promote uniform coating on all surfaces.*

Consolidated Vacuum Corp.



tially a combination of the chrome pickle and dichromate boil, i.e., No. 1 and No. 7. It is most commonly used for wrought products but can be applied to castings. The coating has the varying, matte gray to yellow-red iridescent color of the chrome pickle, plus the brown of the dichromate treatment.

Iridite No. 15 is also a popular treatment for magnesium; its corrosion protection qualities are roughly equivalent to those of Dow No. 7. It produces a light to dark brown coating in 15 sec to 2 min. Total treatment including cleaning and rinsing takes about 6 min—the same as Dow No. 1. The Dow Nos. 7 and 10 treatments take considerably longer since they both require an additional 30 min treatment in a boiling dichromate bath.

How they are applied—Naturally, there is considerable variation in the way different treatments are applied. Dipping is the most common application method, and brushing and spraying are also occasionally used. A minimum of three or four processing steps is required, a typical treatment consisting of alkaline cleaning, rinsing, chromate dipping and rinsing.

Cost factors—Cost of chromate treatments for magnesium also varies considerably. Costs as low as 0.05 to 0.07¢ per sq ft have been quoted for the Dow No. 19 treatment, and 0.2 to 0.5¢ per sq ft for a proprietary treatment. The latter treatment has a minimum equipment cost for small scale operation of about $500 per 100 gal of solution capacity.

TABLE I—HOW MUCH THEY COST AND WHERE THEY ARE USED

Type ↓	Cost, ¢/sq ft[a]	Applications
ORGANIC COATINGS		
Cellulosic	1	Metal novelty goods, art objects
Non-Premium Alkyd	1.75	Architectural and marine products, toys, metal furniture, maintenance applications
Oleoresinous Varnish	1	Toys, novelty goods
Bituminous (thin film)	3	Protect machined parts in storage; crude oil tanks and similar products
HOT DIP METAL COATINGS		
Zinc	0.9	Structural parts, castings, bolts, nuts, nails, hardware
Lead	0.75	Wire, hardware, nuts, bolts, washers, tanks, barrels, cans, chemical processing equipment
Tin	1.6	Food and beverage cans, sanitary equipment, condenser and transformer cans, washers
IMMERSION COATINGS		
Tin	0.06	Safety pins, thimbles, buckles, copper tubing, aluminum pistons
Gold	6	Costume jewelry, trophies, auto trim, novelty goods, printed circuits, transistors, connectors
Silver	0.6	Cheap jewelry, minor electronic parts
Copper	<1	Cheap hardware, coatings on steel wire to improve die forming
VACUUM METALLIZED COATINGS	1	Costume jewelry, hardware, optical reflectors, instruments, appliance and automotive interior trim
CHEMICAL CONVERSION COATINGS		
Chromate Conversion Coatings	0.01-0.5[b]	Aluminum castings, flash reflectors, fuse parts, bolts; various magnesium aircraft and missile parts, typewriters, and other lightweight commercial products; zinc die castings and hardware. See text
Phosphate Conversion Coatings	0.01+	Various steel, aluminum, and zinc-coated parts to aid in cold forming; automotive parts such as pistons and axle assemblies to improve wear resistance; various metal parts to improve corrosion resistance
Oxide and Other Coatings	0.25+[b]	Guns, toys, optical goods, novelties, spark plugs, hardware, appliance parts, sanitary ware, grommets, nuts, bolts, screws
RUST PREVENTIVES		
Oil-Type	0.026	Internal combustion engines, gear cases, hydraulic systems, highly finished auto parts, galvanized products, steel sheet, bar and wire
Wax-Type	0.14-0.67	Any highly finished part
Corrosion Inhibitors	0.33	Most common metal parts during manufacturing, shipment and storage

[a] Approximate costs for materials alone, exclusive of equipment and handling costs. See text for other cost factors.
[b] Depends on base metal.

Coatings for copper

Properties—Chromate coatings for copper alloys have achieved wide popularity because of their ability to provide a bright, tarnish-free finish, to eliminate mechanical buffing, and to prepare a bright surface for chromium plating.

The protective and decorative value of the coating varies with its thickness, the type of treatment, and the particular copper alloy. Corrosion resistance of chromate-coated brass parts, for example, increases with zinc content. Mirror-bright coatings can be obtained on fine grained and homogeneous wrought alloys. Surfaces on coarse grained alloys are bright, but somewhat less smooth in appearance and texture. Heterogeneous alloys such as leaded and beta brass, and phosphor bronze, do not dissolve uniformly during treatment and consequently do not brighten as well as the homogeneous alloys.

The coatings do not flake off during cold forming or bending and do not affect the dimensions of close tolerance parts. They can be spot or shielded-arc welded and provide unusually low contact resistance.

How they are applied—Solid copper alloy parts are treated much the same as aluminum alloys. After alkali cleaning and rinsing the parts are chromate dipped, rinsed and dried. One additional dip and rinse are required if parts are to be dyed.

Cost factors—The cost of treating copper alloy surfaces varies from 0.05 to 0.4¢ per sq ft. Minimum equipment cost for small scale treatment of solid parts is about $500 per 100 gal of solution capacity.

Coatings for silver

Properties—Chromate conversion coatings are applied to silver surfaces to eliminate tarnishing and

corrosion. Color of the coatings varies from clear to yellow, and the degree of tarnish protection depends on coating thickness. Chromated surfaces will have tarnish resistance roughly equivalent to that provided by a good water dip lacquer. As with other chromate treatments, the coatings produce only a small increase in electrical resistance.

How they are applied—Thorough rinsing and neutralizing of any cyanide contamination on silver surfaces is particularly important for satisfactory use. Thus, a neutralizing dip in ½% nitric acid is recommended prior to chromating. Surfaces should be free of water-break prior to chromating.

Cost factors—Cost of treating silver surfaces will vary from 0.02 to 0.1¢ per sq ft. Maximum equipment cost for treating solid parts is about $750 per 100 gal of capacity.

Allied Research Products, Inc.

***Carburetors** and other zinc die castings are chromate treated to improve corrosion resistance.*

Phosphate conversion coatings

Phosphate conversion coatings are noted for their low cost and their ability to: 1) provide corrosion protection, 2) facilitate drawing, extruding and cold forming, and 3) improve scuff and wear resistance. The coatings are also distinguished for their excellent paint bonding properties. However, this property is beyond the scope of this manual as we are mainly concerned with the coatings when they are used alone to improve the properties of a base metal.

Types

Phosphate coatings are mainly used on iron, steel, zinc and aluminum, and to a lesser extent on cadmium, tin and magnesium. A large number of proprietary coatings are available and can be roughly classified as follows:

1. Zinc phosphate (lightweight)
2. Zinc phosphate (medium weight)
3. Zinc phosphate (heavy weight)
4. Iron oxide phosphate
5. Manganese phosphate
6. Amorphous phosphate

Why they are used

For corrosion protection—Unpainted phosphate coatings, treated with suitable oils, waxes or stains, provide excellent corrosion protection, especally on ferrous surfaces. Coatings consisting largely of iron phosphate crystals were originally used for this purpose, but zinc and manganese phosphate coatings are currently favored for corrosion protection. These coatings can be treated with any one of a number of dry film, soft film and nondrying rust preventive finishes and stains, depending on end use.

To aid cold forming—Because of their ability to carry lubricants, phosphate coatings can be used to aid various cold forming operations such as deep drawing, cold heading, extrusion, and wire and tube drawing. At various times all of the phosphate coatings have been used as aids in cold forming; however, zinc phosphate coatings are currently the most widely used.

Coatings have been used to improve the cold working of steel, zinc-coated steel, stainless steel, aluminum and zirconium. In most applications the coatings are impregnated with a soap solution or other lubricant prior to forming. During forming, the coating crystals are deformed or crushed and prevent metal-to-metal contact. As many as four successive draws have been made without intermediate annealing or relubrication. Since the coating is nonmetallic it acts as an antiflux and aids materially in preventing welding and galling. By aiding in cold forming, phosphate coatings provide longer tool life, fewer defects due to scratches, greater reductions, fewer draws, and increased drawing speeds.

To improve wear resistance — Because of their crystalline structure, phosphate coatings are capable of maintaining a continuous film of oil between bearing surfaces. Oil-absorptive manganese phosphate coatings are produced by treating parts in a bath of metal acid phosphates containing free phosphoric acid and accelerators.

On ferrous surfaces the coatings consist of manganese and iron phosphate crystals. Even after the coatings have been worn off, the small pits etched in the bearing surface act as oil reservoirs. Since they are saturated with oil, the coatings provide considerable corrosion resistance and are quite beneficial for parts to be stored.

The acid reaction of the treatment bath also removes burrs, wire edges and other irregularities occurring on the bearing surface. The coatings are quite smooth and are conducive to rapid and safe break-in. Because of dimensional buildup, special care must be given to close tolerance parts.

Phosphate coatings are used in a number of automobile and engine applications to improve wear resistance. Typical of the parts that have

been coated are piston rings, valve lifters and guides, camshafts, rocker arms, cylinder liners, universal joints, gear shift forks, differential gears and automatic transmission parts.

How they are applied

Application methods for phosphate coatings vary with the type of treatment used and the intended use of the part. It is impossible to describe all of the treatments here. However, a typical example of the steps required can be given: namely zinc and manganese phosphate coatings for corrosion protection.

These coatings are usually applied by immersion in weights of 800 to 2500 mg per sq ft. Weight of the coating is a function of immersion time, pretreatment, solution composition and basis metal. Metal parts that have been completely machined, and some stampings and pressed steel parts, may not require preliminary cleaning. However, rough castings and other parts coated with heavy scale, oil or grease require thorough cleaning. Application of the coating is comparatively simple; it requires about five steps, including cleaning and rinsing. Subsequently, the coatings can be treated with any one of a number of dry film, soft film and nondrying rust preventives, depending on the end use.

Cost factors

It is difficult to pinpoint exact cost figures because of the wide range of proprietary materials available and the different number of processing steps required. Costs as low as 0.01 to 0.015¢ per sq ft have been cited for low cost treatment on a production line basis. This figure is admittedly low, and the cost of treating intricately shaped parts will be higher, although still less than 1¢ per sq ft. For example, production experience has shown that an average cast iron engine piston can be phosphate treated for about 0.5¢. Similarly, it costs less than 1¢ to treat an average automotive axle assembly consisting of drive pinion, side gears, pinion mates, shaft, spacer and washers. These costs are for the chemicals alone, and labor and handling costs must be added.

Oxide and other coatings

Oxide coatings, similar to the phosphate and chromate conversion coatings described above, are quite inexpensive and can be applied to a variety of metals such as iron, steel, zinc, cadmium, copper and aluminum. They are usually quite thin, often have a characteristic color, and are used primarily for decoration, for corrosion protection, or as a paint base.

Coatings for iron, steel

Properties — Next to phosphate coatings, black oxide coatings are the most widely used conversion coatings for iron and steel. The coatings are composed essentially of the black ferro-ferric oxide of iron and can be produced by several methods, the hot alkali-nitrate method being the most popular.

Black oxide coatings can be applied to cold rolled (low carbon) steel, high carbon steel, low and high carbon alloy steels, and gray and malleable iron. They can also be applied to stainless steel, but may lower the metal's corrosion resistance. Consequently a black sulfide treatment is recommended for stainless.

Other oxide treatments are also available for iron and steel, including the browning process, the Carbonia process, oven heating, salt bath immersion and the steam process. All of these treatments are comparatively inexpensive and probably competitive with the alkali-nitrate treatment. However, none are as popular as the alkali-nitrate method and therefore they will not be discussed here. (For detailed information see "Conversion Coatings for Metals," M/DE, Aug. '57, p 121.)

The chief advantages of black oxide coatings produced by the alkali-nitrate treatment are their: 1) attractive appearance, 2) abrasion and chipping resistance, 3) low coefficient of friction, and 4) economy and ease of application.

Appearance of the coatings depends largely on metal surface condition. Attractive shiny coatings are obtained on highly buffed surfaces; dull matte coatings are obtained on etched, brushed or sandblasted surfaces. Thickness of the coatings ranges from 0.04 to 0.2 mil, and the dimensional change produced is usually less than 0.01 mil.

The corrosion resistance provided by black oxide coatings is relatively low. Coatings are not recommended for outdoor use; however, indoor protection can be considerably improved by impregnation with oils, waxes or lacquers. Typical low cost applications include gun parts, toys, optical goods, spark plugs, and screws, nuts and bolts.

How they are applied—At least five processing steps and processing tanks are required for the hot alkali-nitrate, black oxide treatment. A minimum sequence includes alkali cleaning, rinsing, dipping in the coating solution, rinsing, and a final dip in a rust preventive oil or wax solution. An additional acid pickle and rinse may be required after cleaning to remove rust and scale. A chromic acid dip is also occasionally used after the oxide treatment. Most parts can be treated in about 5 min; however, heat treated parts take about 10 to 15 min. An additional 5 min should be allowed for parts to drain and dry.

Cost factors—Most black oxide coatings for ferrous metals cost about 0.25¢ per sq ft for chemicals alone. Labor and heating costs must, of course, be added to this figure. Equipment costs vary widely with the number of parts to be treated. A minimum manually operated installation using custom-made tanks costs about $1000. A completely automated installation for high speed production costs about $60,000.

Black oxide coatings for copper

Properties—Black oxide coatings can be used for decorating and improving the corrosion resistance of alloys containing 65% or more copper. Coating thickness ranges from 0.05 to 0.2 mil, dimensional change being about 0.5 mil. The coatings are extremely adherent, will withstand considerable handling and wear, and can be used up to 400 F. When protected with a hard wax or oil, they will withstand over 200 hr of salt spray before breakdown.

How they are applied—Following is a typical procedure required for treating alloys containing over 90% copper (including electroplates). First, surfaces are prepared according to whether a dull or glossy finish is needed—buffing being required

What About Precoated Metals?

As mentioned in the introduction we are mainly concerned in this manual with coatings that are applied to parts after they have been fabricated. However, sheet metal parts can often be finished more cheaply by using precoated sheet rather than unfinished sheet that requires subsequent finishing. Precoated sheet or strip has a number of important cost advantages:

1. It comes ready to use; thus the user does not have to buy any equipment or hire any coating specialists. Also, use of precoated sheet can relieve the burden on finishing equipment that is available but tied up on other products.

2. Having been made under unvarying, controlled conditions, it is of uniform high quality.

3. Because it is made by mass production methods, the as-applied cost of the coatings is low.

Naturally, a close cost analysis should be made of the relative merits of using precoated metal or doing the finishing yourself. For example, let's assume that the product is to be made of an intermediate gage sheet, such as 20-gage cold rolled steel. A typical price for this material is 10¢ per sq ft, unfinished. The same material galvanized would cost only 12¢ per sq ft.

In addition to zinc, other materials discussed in this manual, such as lead, tin and some organic coatings, are available in precoated sheet. Although electroplates are not discussed here, it should be noted that many electroplates and base metals are available in precoated form. Typical of these are preplated nickel and chromium coatings on steel, zinc, brass, copper and aluminum bases. As an example of how much they cost, 0.025-in. steel sheet plated on one side with nickel is priced at about 28¢ per sq ft.

for a glossy finish, and matte brushing or etching for a dull finish. Any deposits left by mechanical finishing are cleaned off and oxides or stains on surfaces removed. After rinsing, surfaces are treated in the blackening solution and then rinsed again.

Cost factors—Black oxide coatings for copper and its alloys are somewhat higher than coatings for steel—about 1.7¢ per sq ft. Equipment costs are about the same as for steel.

Other coatings for copper

In addition to oxide coatings a considerable number of other inexpensive decorative and functional coatings are available for copper. A black coating can also be produced by immersion in a potassium sulfide solution. A royal copper (wine) color can also be obtained on copper. A variety of colored treatments are available for yellow brass, including brown, gold, blue-black, light green, steel gray and statuary bronze. (For comprehensive information on these finishes see "Maintenance, Cleaning, Finishing and Coloring of Copper, Brass and Bronze," published by Copper & Brass Research Assn.)

Coatings for zinc, cadmium

Properties—A number of low cost black oxide coatings are available for blackening cadmium electroplates and all zinc surfaces including electroplates, sheet, galvanized surfaces and solid parts. The coatings are primarily intended for decorative use and as a paint base, and will withstand normal handling and wear. They can withstand exposure to normal atmospheres, but should be treated with wax, oil or a lacquer if outdoor protection is needed. The coatings on zinc are 0.04 to 0.1 mil thick and increase dimensions about 0.5 mil.

How they are applied—Both zinc and cadmium are treated the same: surfaces are rinsed, given an acid dip, rerinsed and then blackened. Zinc die castings are either buffed or coated as-is, depending on the quality of finish needed. They are cleaned and activated, given a dilute acid dip, blackened, and then rinsed.

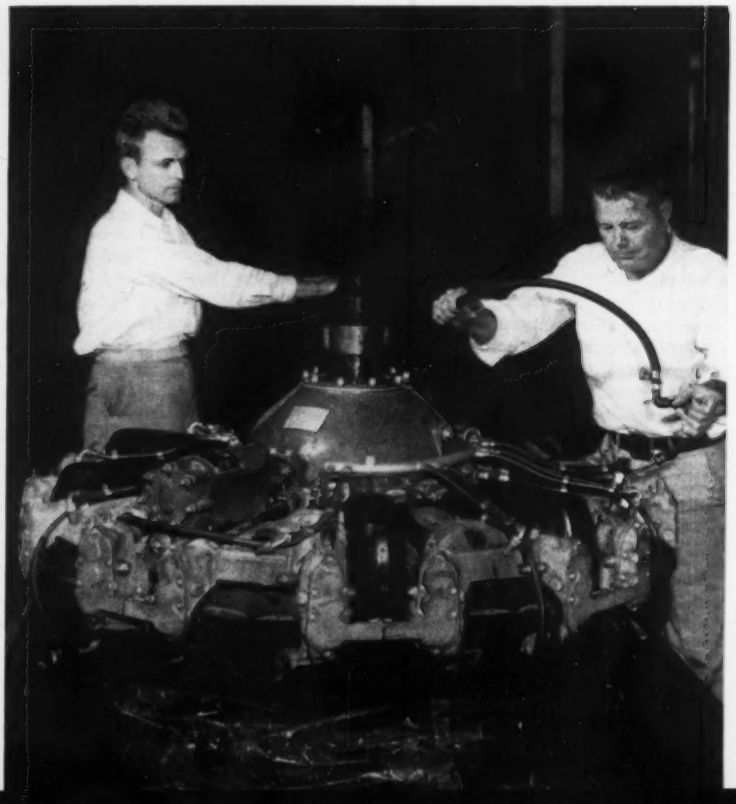
Cost factors—The cost of materials for finishing zinc surfaces is relatively low—less than 0.5¢ per sq ft. Keep in mind that up to ten processing steps may be required and handling and equipment costs may be high. However, the treatment is quite suitable for small parts, and bulk finishing in baskets or tumbling cylinders is readily done.

Oxide coatings for aluminum

Properties—A large number of proprietary oxide coatings can be

***Engines** can be protected for long periods with rust preventives which are easily removed at time of use.*

Esso Standard Oil Co.



used to protect and decorate aluminum. They provide a fair amount of corrosion protection, retain an attractive dyed finish, and can be applied easily and cheaply (they also serve as an excellent paint base).

Most coatings can be dyed but their colors are not as lightfast as colored anodic coatings. They are relatively thin (0.03 to 0.17 mil) and produce small dimensional changes—on the order of 0.1 mil.

How they are applied—Oxide coatings can be applied to most wrought and cast aluminum alloys. Thorough cleaning and rinsing is required before treatment and surfaces are sometimes etched or buffed, depending on the surface effect desired. Following pretreatment, parts are immersed in the oxide coating solution which essentially consists of soda ash and potassium dichromate. The parts can then be given an optional dyeing treatment. In addition, the coating can be sealed in a hot dichromate solution, depending on the relative corrosion resistance required. Total treatment time varies from 5 to 20 min.

Cost factors—Cost of oxide coatings on aluminum is roughly the same as that of chromate conversion coatings. Estimates of 2 to 4¢ per sq ft (including materials, labor, overhead, etc.) have been given by aluminum producers. By comparison, the highest figure given for a chromate coating is 0.3¢ per sq ft (this figure does not include labor, overhead, etc.).

Other coatings for aluminum

Caustic etch—Most of the other chemical treatments for aluminum are mainly designed to improve and preserve the metal's appearance. One of the most popular treatments is a caustic etch that produces a decorative silvery-white appearance. It can be produced in various textures such as matte, soft lustrous, and dull frosted, and has the added benefit of eliminating minor surface imperfections.

Etching action is provided in a solution of caustic soda or sodium hydroxide by immersion for 5 to 10 min. This is usually followed by a smut removal operation. (For extra resistance to marking or fingerprinting, surfaces may be additionally protected with a clear organic coating or else given an anodic treatment.)

Cost of the caustic etch treatment is about 1 to 2¢ per sq ft, exclusive of subsequent anodizing or painting, but including materials, labor and overhead costs.

Acid etch—A matte finish can also be produced on aluminum by an acid etching process quite similar to caustic etching. Acids that can be used include hydrochloric, hydrofluoric, nitric, phosphoric and sulfuric. Cost is roughly the same as for caustic etching.

Chemical brightening—This treatment is principally used to give a mirror-bright or specular finish to aluminum. It is frequently applied to polished or buffed surfaces which are then protected with a clear anodic coating. Like the etched finishes, it is not usually used alone as a complete finishing treatment.

Rust preventives

Rust preventives are essentially petrolatum-type coatings designed to provide low cost corrosion protection of parts during manufacturing, shipment and storage. Although some types can be used for as long as three years, they are mainly intended for temporary protection and must usually be removed when the parts are ready for use. They are very rarely used for decorative purposes, although some hard types have a pleasing, glossy appearance.

Literally dozens of distinct formulations have been made available for a wide range of products and operating conditions. Many of these formulations are specially designed to meet a military specification. In general, the materials can be classified as follows:

Oil type (cold application)

Properties and uses—This group of rust preventives consists of non-setting, non-drying oils of various weights and viscosities. The coatings are usually quite thin after drainage (roughly 0.2 to 0.3 mil); however, low viscosity types are available where thick coatings are needed. They all have a clear, transparent appearance.

Almost all of the non-drying oil types are intended for indoor use and provide protection for periods up to eight months, depending on the grade used. Tests show that they can protect surfaces for up to 30 days at 100% RH and 100 F. They can be used to protect:

1. Internal combustion engines and parts during shipment and storage.
2. Gear cases, hydraulic systems and highly finished auto parts.
3. Sheet steel, bar stock and wire, and galvanized products.

How they are applied—For rust preventives to perform effectively they should be applied over clean surfaces. Surfaces should be cleaned by alkaline, solvent or emulsion cleaning, and scalely surfaces should be freed of all deposits by mechanical cleaning.

All of the coatings can be applied by spraying, dipping, brushing or flushing. Aside from draining, no post-treatment or drying time is necessary, the coatings being used as is. However, keep in mind that the coatings have to be removed at time of use. Removal is usually done by petroleum solvent rinsing, vapor degreasing, emulsion spraying or alkaline washing.

Cost factors—The cost of oil-type rust preventives depends on the coverage required for the product and on the service conditions. Coverage can vary from 500 to 5000 sq ft per gal, an average figure being about 2500 sq ft per gal (0.2 mil). Using a typical cost of 65¢ per gal and a coverage of 2500 sq ft, the cost works out to the low figure of 0.026¢ per sq ft. This is the cost of the coating alone and does not include the supplementary cost of cleaning the surface, actually applying the coatings, and removing the coatings when the parts are ready for use.

Solvent type (cold application)

Properties and uses—Solvent-type rust preventives consist of petroleum products in conjunction with various chemical compounds designed to give added corrosion resistance. Like the non-drying types, they are quite thin; they are usually used in thicknesses of 0.2 to 0.4 mil—occasionally up to 2 mils. They range from light, transparent, oily materials on up to hard, black coatings very similar in appearance to varnish or paint.

In general, most of the soft types are intended for indoor use for periods from four months to two years, depending on the type used.

Typical applications for the soft types include:

1. External and internal surfaces of machinery and tools not subject to handling or long term indoor storage. Also lubrication and fuel systems of internal combustion engines.

2. Protection of steel sheet, bar and wire, engine cooling systems, and highly finished surfaces between manufacturing operations.

As is to be expected, the hard solvent types of rust preventives provide better corrosion protection than the soft types. With some exceptions, they can be used both indoors and outdoors. The best material, a firm, brown, waxy coating, will protect surfaces indoors up to three years, outdoors up to two years. This rust preventive is specially formulated for external surfaces of machine tools, engines, automotive parts and other metal products in long term outdoor and indoor storage. Similar coatings are available for less severe applications.

How they are applied—With a couple of exceptions, the solvent-type rust preventives are applied the same way as the soft types and require the same metal pretreatment. Soft types are ready for use immediately after application but hard types require about ½ to 4 hr to air dry. With some exceptions, all of the coatings are easily removed.

Cost factors—Cost of solvent-type rust preventives depends on the end application and the coverage required. Basic cost of the soft type materials is 90¢ per gal. Thus, heavy soft coatings with a coverage of 1000 sq ft per gal (2 mils) cost about 0.09¢ per sq ft. And lighter soft coatings with a coverage of 4500 sq ft per gal (0.04 mil) cost about 0.02¢ per sq ft.

In general, hard types cost more than soft types because they are intended for heavier duty applications and are applied in greater thicknesses. Cost of hard materials is roughly 80¢ per gal. Thus, a typical hard coating with a coverage of 800 sq ft per gal (1 mil) costs 0.1¢ per sq ft.

Wax type (hot application)

Properties and uses — Wax-type rust preventives are designed for both indoor and outdoor use, and have end properties quite similar to those of solvent-type rust preventives. Many different formulations are available. The coatings come in soft, semi-hard and hard consistencies. Some coatings are clear and dull; others have a tan, opaque appearance; and still others have a glossy black finish. The coatings are principally used to protect highly finished parts for prolonged periods indoors or outdoors; e.g., indoor storage of ball bearings.

How they are applied—Like other rust preventives, wax types should be applied over thoroughly clean surfaces. Non-emulsion types must be heated to 165 to 200 F for application and, because of their heavy consistency, are usually applied by dipping or brushing rather than spraying or flushing. However, some emulsion types can be sprayed, usually at a coverage of 2000 sq ft per gal. Air drying time of this type ranges from 10 to 20 min.

When parts are ready for use the coatings can be readily removed in a petroleum solvent or alkali cleaner.

Cost factors—Although they are applied in heavy thicknesses, wax-type rust preventives are still relatively cheap. Coverage of non-emulsion types ranges from 3 sq ft per lb for heavy coats, to 125 sq ft per lb for light coats. Average coverage is about 15 sq ft per lb or 1.5 mils. Thus, at a price of 10¢ per lb, the cost of non-emulsion types works out to 0.67¢ per sq ft. By comparison, emulsion types cost about 0.14¢ per sq ft, but they are not as corrosion resistant as the hot dip types. Cleaning, removal and other handling costs must be added.

Corrosion inhibitors

Some of the petroleum-base rust preventives described above are occasionally referred to as corrosion inhibitors, and the term is also frequently used to describe materials that are added to plating baths to prevent corrosion. However, the following discussion applies only to corrosion inhibitors that do not contain petroleum products and are used alone on metals as a complete finishing system for corrosion protection.

Properties and uses—Typical of this type of corrosion inhibitor is an organic compound containing synthetic inhibitors which are deposited at grain boundaries of the base metal. The material forms a continuous molecular film which displaces any moisture present on the surface and forms a barrier against subsequent deposits of water. The material is effective at temperatures from –60 to 400 F. It provides long term protection indoors, but if subjected to severe outdoor exposure and abrasion its effectiveness may be reduced to several days duration. It is not recommended for exposure to flowing currents of water or for direct submersion in strong, corrosive chemicals.

The material can be used to protect iron, steel, aluminum, copper, brass, magnesium and other common metals during manufacturing, storage and shipment, and as a maintenance coating.

How it is applied—Although maximum effectiveness is obtained over clean surfaces, the corrosion inhibitor is frequently used over surfaces in the as-received condition. Depending on the size of the part, the inhibitor is applied by spraying, brushing or dipping.

Cost factors—Cost of the corrosion inhibitor is $6.50 per gal and it covers about 2000 sq ft per gal. Thus, the applied cost works out to 0.33¢ per sq ft. Although this figure is high compared to petroleum-base rust preventives, keep in mind that surfaces do not usually have to be cleaned and that the coatings do not have to be removed when parts are ready for use.

Acknowledgments

The author would like to express his appreciation for the assistance of personnel and literature from the following companies in preparing this article:

Allied Research Products, Inc.
Aluminum Co. of America
Amchem Products, Inc.
American Hot Dip Galvanizers Assn., Inc.
American Nickeloid Co.
American Zinc Inst.
Armco Steel Corp.
Auromet Corp.
Bee Chemical Co.
Consolidated Vacuum Corp., Div. of Consolidated Electrodynamics Corp.
Corrosion Reaction Consultants, Inc.
Dow Chemical Co.
Electrochemical Industries, Inc.
Engelhard Industries, Inc.
Enthone, Inc.
Esso Standard Oil Co.
Harry Miller Corp.
Hercules Powder Co.
Lion Oil Co., Div. of Monsanto Chemical Co.
Lead Industries Assn.
Maas & Waldstein Co.
Metal & Thermit Corp.
Midland Industrial Finishes Co.
Mitchell-Bradford Chemical Co.
Panther Chemical Co.
Parker Rust Proof Co.
Pennsylvania Refining Co.
Reynolds Metals Co.
Sel-Rex Corp.
Shawinigan Resins Corp.
Shell Chemical Corp.
Smith Oil & Refining Co.
Standard Oil Co. (Indiana)
Thomas Strip Div., Pittsburgh Steel Co.
Tin Research Inst., Inc.
Union Carbide Plastics Co., Div. of Union Carbide Corp.
Valvoline Oil Co., Div. of Ashland Oil & Refining Co.
Western Reserve Laboratories

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first in silicones

Dow Corning

SILICONE NEWS

for design and development engineers • No. 72

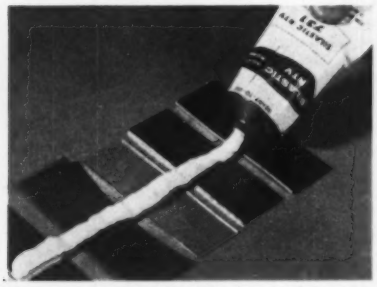
NEW AND HANDY

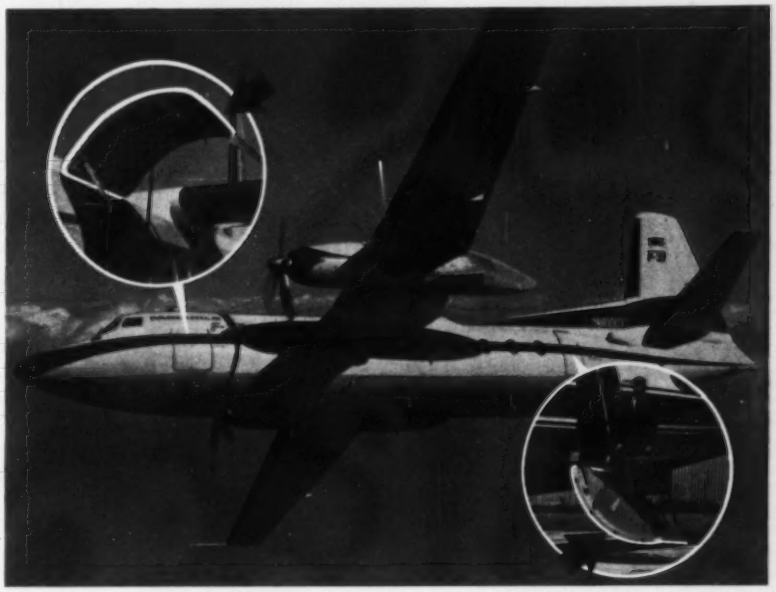
A new ready-to-use silicone rubber holds promise of high utility in a range of diverse applications.

Silastic® RTV 731, a single-component silicone rubber that cures at room temperature, is Dow Corning's newest addition to its series of silicone rubbers.

A unique advantage is that Silastic RTV 731 requires no catalyst premixing . . . can be applied easily from the tube that serves as an applicator or dispenser. Silastic RTV 731 provides excellent adhesion to most clean surfaces including metal, glass, ceramic, and plastic — adheres very well to laminates made with silicone resin or silicone rubber too.

Silastic RTV 731 needs only exposure to air to accomplish vulcanization, becomes tack-free within an hour, cures to a tough, rubbery solid in 24 hours. Applied to vertical surfaces, Silastic RTV 731 stays put—shows no tendency to sag, slump or flow prior to vulcanizing. (*Cont. pg. 2*)





SEALS BELOW 50 BELOW

Hot or cold . . . you can count on Silastic®, the Dow Corning silicone rubber, to maintain a positive, airtight seal. This fact helped designers at Fairchild Engine & Airplane Corp., Hagerstown, Maryland, handle a tricky gasketing problem on their new F-27 prop-jet transports.

Fairchild recently supplied a number of F-27B's to Northern Consolidated Airlines for service in northern Canada and Alaska. These craft were especially equipped with an oversize cargo door capable of admitting large heavy equipment for transportation into remote northern areas. Sealing the oversize cargo door, and the passenger door, too, might have been a real problem because of the bitter cold encountered by these aircraft at high altitudes . . . and ground temperatures often dip to 50 below zero! But, sealing was no problem at all . . . with gaskets made of Silastic. They never become hard and brittle, regardless of sharp temperature variations encountered in service.

The fact is that Silastic readily withstands prolonged exposure to temperatures as low as —130 F . . . or as high as 500 F. It retains an exceptionally high order of strength and resiliency, has a very low compression set, resists weathering, ozone, and corona . . . provides the ultimate in all-weather seal efficiency. *No. 241*

TYPICAL PROPERTIES OF SILASTIC FOR SEALS

Temperature range °F	—130 to 500
Tensile strength, psi	600 to 1500
Elongation, %	150 to 400
Tear strength, lb/in	40 to 180
Compression set, %, @ 300 F	5 to 50
Hardness range, Durometer	25 to 80
Weather, ozone and corona resistance	Excellent

"COOL" COOLANT

The properties of silicone fluids have helped Hallicrafters Company design and produce lighter, less costly, more versatile heat exchangers for cooling airborne, shipboard and ground support electronic devices.

These highly efficient Hallicrafter units are offered in three standard models with ratings up to 7,000 watts dissipation. They are designed and produced to meet environmental conditions outlined in MIL-E-5272 and MIL-E-5400. All may be used with standard racks, and operate with maximum efficiency up to 70,000 feet at 71 C.

Among the properties that make Dow Corning silicone fluids ideal media for these heat exchangers are a unique relatively flat viscosity-temperature slope and a high degree of thermal stability and oxidation resistance. These semi-inorganic fluids maintain near constant viscosity over a range from —65 to 250 C. They can be pumped at high speed without suffering breakdown due to shear . . . pump easily at low temperatures . . . have good lubricity . . . won't vaporize at elevated temperatures . . . will not oxidize or corrode metals.

In sum, Dow Corning silicone fluids aid heat exchange units to operate uniformly and almost indefinitely, as far as the coolant is concerned. *No. 242*

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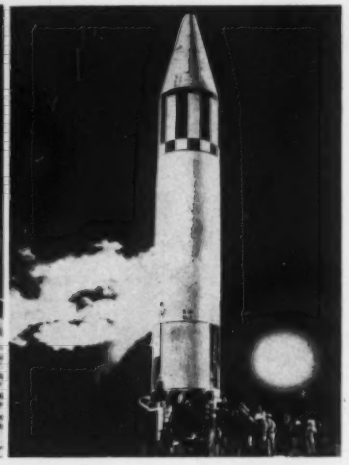
MORE



AID MISSILE RELIABILITY

Because they best withstand rigorous space age environments, silicone-glass laminates serve as terminal boards in the black boxes for the Jupiter missile's electronic control system.

Chrysler Corporation Missile Division engineers specified silicone-glass laminates for numerous uses throughout the electronic control system of the Army-developed Jupiter missile.

Here are reasons why: Extensive testing has proved that glass laminates made with Dow Corning silicone resin retain excellent dielectric properties in spite of heat, moisture, environmental aging, rapidly changing ambients, vibration and shock.

In service, silicone-glass laminates have excellent resistance to ozone, arcing and corona; in storage, to fungus attack. Glass laminates made with Dow Corning Silicones are designed to meet MIL-P-997B, are highly reliable dielectrics for all units subject to adverse environments, serve well even when exposed to high humidity and high voltage conditions.

Other advantages: Silicone-glass laminates are easy to work with, fabricate and assemble; have good physical properties; show excellent resistance to creep under pressure; aid production schedules because soldering heat doesn't loosen terminals while wiring is secured. *No. 243*

NEW AND HANDY *(Continued)*

The properties of Silastic RTV 731 point to its practicality in many applications similar to those of presently available room temperature vulcanizing silicone rubbers . . . and in numerous new applications, too . . . with the advantages of greater ease of application and better, stronger bond to practically all surfaces.

Sample tubes of Silastic RTV 731 may be obtained for evaluation in your application. Request sample on company letterhead, addressing Dept. ..... *No. 244*

TYPICAL PROPERTIES OF SILASTIC RTV 731 AFTER VULCANIZING 24 HOURS AT 77 F

Color	White
Brittle Point, degrees F	−100
Volume Coefficient of Thermal Expansion	9.3×10^{-4}
Thermal Conductivity, cal per cm (degrees C.) (sec.)	0.495×10^{-3}
† Durometer Hardness, Shore A Scale	25
† Tensile Strength, psi	200
† Elongation, percent	250
Serviceable Temperature Range, continuous	−70 to 300 F
short term	to 500 F

† After vulcanizing for 24 hours at 77 F in 1/8" thick cross section.

new literature and technical data on silicones

TACKLES MANY JOBS — An article reprinted from **Power** tells how silicone insulation has proved to be a useful asset in most every type of electrical equipment ranging from dry type transformers to wire and cable. Exceptional thermal endurance and stability of insulation made with Dow Corning silicones have spurred its use in today's electrical equipment, as evidenced by subjects covered in this article. *No. 245*

DON'T MISS THEM at the IRE show in New York, March 21 thru 24. Dow Corning booths No. 4103 and No. 4105 will be filled with displays of silicone materials that help electronic units operate reliably — even in the toughest environments. If you can't be there, get information now about these aids to better electronic design. *No. 246*

UP-TO-THE-MINUTE. The new **Engineering Guide to the Properties and Applications for Dow Corning Silicone Products** is now available. This 16-page brochure contains the most current information on all lines, all forms of silicone products manufactured by Dow Corning for engineering applications. Bring your reference files up-to-date by encircling. *No. 247*

SEA HUNT — Fine performance of sonar transducers and similar underwater electronic devices depends largely on fluids with uniform sound transmission characteristics. Dow Corning 220 Fluid, developed especially for use as a sound transducer fluid, provides many desirable properties including heat stability, near-uniform viscosity over a wide temperature span, oxidation resistance and good electrical properties. *No. 248*

NEW ADHESIVE — Silastic Adhesive 140, the ready-to-use adhesive that sets up at room temperature, provides an excellent means of bonding air-vulcanized and/or oven-cured silicone rubber to itself, to metals, to glass, or to a variety of organic rubbers and plastics. The data sheet on this new product details properties of Silastic Adhesive 140, and cites bond strengths between different combinations. A valuable new product for consideration. *No. 249*

Dow Corning Corporation, Dept. 7003 Midland, Michigan

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FILE FACTS

Mechanical Properties of Imported Woods[a]

Source, Species	Moisture Content, %	Specific Gravity (oven dry)	Static Bending: Mod of Rupture, 1000 psi	Static Bending: Mod of Elast, 10^6 psi	Max Crush Str (par. to grain), 1000 psi	Hardness, lb[b]: End	Hardness, lb[b]: Side	Max Shear Str (par. to grain), psi
TROPICAL AMERICA								
Balsa	5.0	0.144	2.2	0.46	1.0	—	—	—
Banak	11.4	0.50	11	2.04	5.1	560	510	980
Brazil Rosewood	5.7	0.72	—	—	—	—	2130	—
Caribbean Pine	13.1	0.78	16.7	2.24	8.5	1180	1240	2090
Cativo	81.2	0.44	5.9	0.94	2.5	460	440	860
Cocobolo	5.7	1.06	—	—	—	—	3860	—
Greenheart	14.8	1.06	25.5	3.7	12.9	2140	2630	1830
Lignum Vitae	12	1.09	—	—	11.4	3600	4500	—
Mahogany	12	0.50	11.1	1.43	6.4	880	760	1050
Parana Pine	12.8	0.50	12.4	1.65	6.7	1100	790	1750
Prima Vera	12	0.44	10	1.2	6.5	1060	730	—
Spanish Cedar	12	0.38	7.9	1.01	4.5	580	500	—
Andiroba	65.0	0.60	10.3	1.69	4.8	940	880	1220
Angelique	78.7	0.69	11.4	1.84	5.6	1100	1100	1340
Beefwood	47.6	1.03	17.3	2.7	8.7	2160	2230	1900
Goncalo Alves	46.2	0.95	12.1	1.94	6.6	1640	1910	1760
Guayacan	35.4	1.00	18.5	2.58	7.7	2270	2530	2140
Lemonwood	14.2	0.78	22.3	2.27	9.7	2140	1940	2120
Purpleheart	13.9	1.05	25.1	3.64	13.3	3350	3640	2070
Santa Maria	13.1	0.60	14.6	1.83	7.0	1410	1150	2080
White Peroba	15	0.73	17	—	7.8	—	1035	—
AFRICA								
African Mahogany	12	0.47	10.7	1.48	5.7	1080	790	1340
Afrormosia	12	—	19.4	1.81	10.3	—	1560	—
Agba	12	—	11.3	1.21	5.7	990	700	1375
Ayous	12	—	8	0.85	3.9	690	430	990
Iroko	12	—	12	1.36	7.0	1340	1100	1710
Limba (Korina)	10.3	—	8	1.27	5.7	—	—	1340
Makore	12	—	13	1.42	6.2	1560	1380	—
Movingue	12	—	15	1.76	8.0	1650	1230	1860
Okoume	12	—	7.4	1.15	10.4	—	1560	980
Sapele	12	—	10	1.45	8.3	1670	1380	—
Utile	12	—	14.2	1.67	8.4	1790	1260	2160
Zebrawood	5.4	—	—	—	—	—	1745	—
Ebony	12	—	26	2.73	12.9	3430	3220	2480
ASIA								
Apitongine	12	—	12.3	1.94	6.2	910	880	1330
Japanese Birch	12	—	14	1.63	8	1600	1090	1350
Japanese Oak	12	—	14.2	1.67	8.3	1830	1220	1180
Philippine Mahogany	12	0.57	12.3	1.69	6.8	780	840	1570
Teak	52	—	11.4	1.67	5.9	915	1038	1107
White Seraya	73	—	8	1.43	4.4	660	605	880
Boxwood	4.6	0.99	—	—	—	—	3220	—
East Indian Laurel	5.8	0.90	—	—	—	—	3160	—
East Indian Rosewood	12	0.79	17	1.77	9.1	2960	3170	2070
East Indian Satinwood	5.4	0.79	—	—	—	—	2315	—
Macassar Ebony	6.1	1.15	—	—	—	—	5030	—
OCEANIA[c]								
Australian Maple	6.1	0.69	14.5	2.09	—	—	1385	—
Blackbean	—	—	13	1.69	6.1	—	—	2477
Ironbark	—	—	18	2.66	9.4	—	—	1896
Koa	6.2	0.59	—	—	—	—	1205	—
Oriental Wood	12	—	14	1.78	9.0	1720	1400	2140
Yuba	6.0	0.65	—	—	—	—	1035	—

[a]First grouping under each geographical region lists woods imported in relatively large volume; second group in each region indicates some of the low volume imports, all of which have densities averaging at least 44 lb per cu ft (air dry).
[b]Load required to embed an 0.444-in. ball to half its diameter.
[c]All relatively low volume.
Source: Adapted from J. L. Stearns, *Forest Products Jnl.*, Nov '58.

The products are the same . . . the difference is the name—Delco Moraine. Now every product that comes off our family tree (formerly Moraine Products Division of General Motors) bears this new name for quality automotive parts. It's a name you can trust, too. For it's backed by almost a quarter of a century of experience in the manufacture of such dependably made products as engine bearings, sintered metal parts, brake assemblies, power brakes, brake fluid, porous metal filters and friction materials. So be sure to remember our new name. It's **DELCO MORAINE**

DEPENDABLY MADE

Delco Moraine, Division of General Motors, Dayton, Ohio

For more information, turn to Reader Service card, circle No. 367

MATERIALS AT WORK

...AT A GLANCE

Cemented carbide balls are solving ball point pens' major drawback: skipping and sliding. The tiny balls, which are 0.039 in. in dia, are ground to a rough finish (approx 10 μ in.) which is said to both grip the paper and provide channels for the ink to follow. Cemented carbide's major advantages: 1) its high hardness prevents the surface from wearing smooth; 2) its excellent corrosion resistance prevents damage from detergent-type inks; and 3) it has better wettability than stainless steel or artificial sapphire. To date, more than 50 million cemented carbide balls have been produced.

Source: General Electric Co.

The switch from painted steel to high density polyethylene has resulted in improved appearance and reduced costs in the design of front-seat side shields used in 1960 Fords. Although the initial reason for the switch was "styling advantages," the new injection molded shields were found to be lighter, 30% less expensive, more resistant to scuffs and dents, and easier to manufacture. Of the plastics tested only high density polyethylene "possessed the required properties at the lowest price."

Source: Phillips Chemical Co.; used by Ford Motor Co.

Some 66,000 tons of steel will be used in this country's first underground missile-launching base now being built at Lowery Air Force Base near Denver, Colo. The base will consist of six subterranean complexes, each containing three steel and concrete silos. Each silo measures 40 ft in dia and over 150 ft deep, and is capable of housing a ready-to-fire Titan ICBM. Of the 66,000 tons of steel used, 28,000 tons will be reinforcing steel, 12,000 tons structural shapes and plates, 10,000 tons corrugated tunnel liner and 10,000 tons pipe. Each silo will be sealed over with heavy steel doors which will protect the complexes from everything but a direct atomic hit.

Source: American Iron & Steel Institute.

A nylon dust guard has solved a maintenance problem that has long plagued the railroad industry. The problem was to find an inexpensive method of protecting journal boxes from contamination while retaining the oil within. Many materials were tried, including plywood, paper, leather, rubber and nearly every known plastic. Molded nylon was selected because it is exceptionally resistant to impact, will not lose its original shape, fits snugly on the dust guard seat, and is resistant to both high and low temperatures.

Source: Plastics & Coal Chemicals Div., Allied Chemical Corp.; dust guard manufactured by DO Co.

Platinum-clad stainless steel is now being used for laboratory ware and various chemical processing apparatus. Advantages of this relatively new material are: four times greater strength than solid platinum at about one-sixth the cost; longer life; greater thickness; and suitability at temperatures up to about 1000 F. The platinum (actually an alloy containing 0.5% rhodium to prevent grain growth) is clad to a corrosion resistant, high nickel-chromium stainless steel by a patented "solid-phase bonding process without diffusion or brazing."

Source: Metals & Controls Div., Texas Instruments, Inc.

RIEHLE-LOS FATIGUE TESTING MACHINES

First to combine static and dynamic testing capabilities

Featuring a basic system of compatible components, new RIEHLE-LOS Hydraulically-Actuated Fatigue Testing Machines permit far greater variety and versatility in testing programs than is possible with any other machine. Available in models with capacities ranging from 12,000 to 300,000 pounds, new RIEHLE-LOS machines can be used to perform dynamic tests as well as conventional static tests.

Using the basic system of console, pulsator and loading unit, both alternating and fluctuating loadings on test specimens can be applied. Infinitely variable frequencies between 125 and 1000 c.p.m. can be obtained while the machine is being operated by the pulsator. A slow-cycle control accessory can be connected to provide frequencies from about 5 to 100 c.p.m.

By including RIEHLE recording and strain measuring instrumentation in the system, conventional static testing can be performed on the new machines. Tension and compression tests are done in the same space, so transition from one to the other is easily accomplished.

Other accessories which can be integrated to extend the utility of the machines include a programmer to automatically vary load levels and frequency and General Purpose Testing Cylinders for testing large parts and assemblies.

Installation is simplified because new RIEHLE-LOS Fatigue Testing Machines are floor models, requiring no pit.

OTHER RIEHLE TESTING MACHINES: Hydraulic and Screw Power Universal Testing Machines, Construction Materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testing Machines, Portable Hardness Testers for Rockwell Readings, etc.

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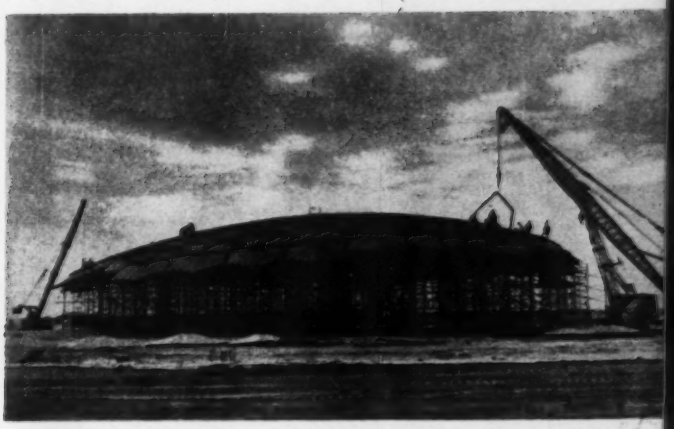
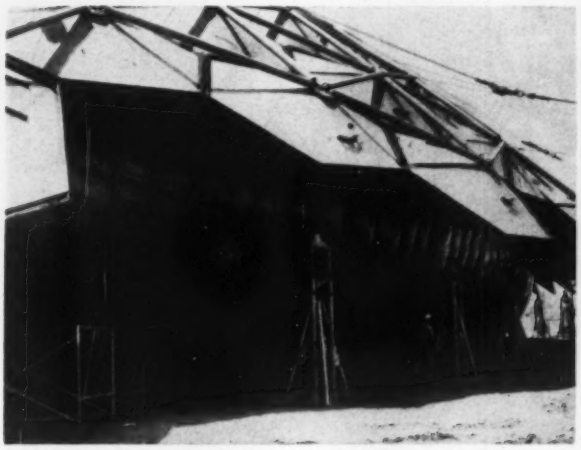
CITY ZONE STATE

All-Welded Steel Dome Built from Top to Bottom

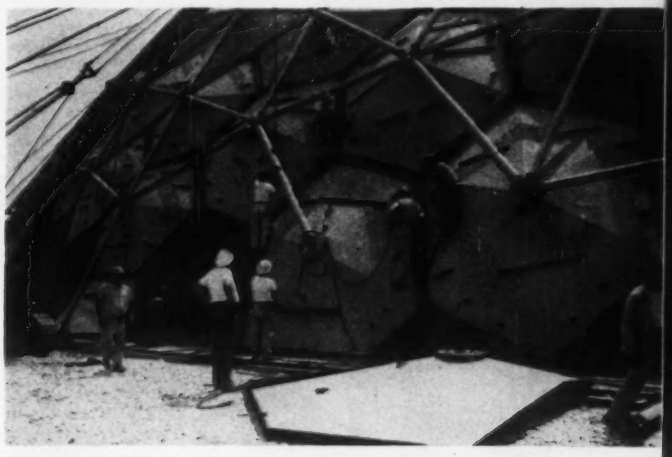
Geodesic dome building, *shown partially completed, is being built from the top down by using a giant air-inflated nylon fabric lifting diaphragm to raise the dome to successively higher levels.*



Construction began *with fabrication of the top center section of the dome on a scaffold. The nylon diaphragm was then attached to the underside of the dome at the 175-ft diameter point.*



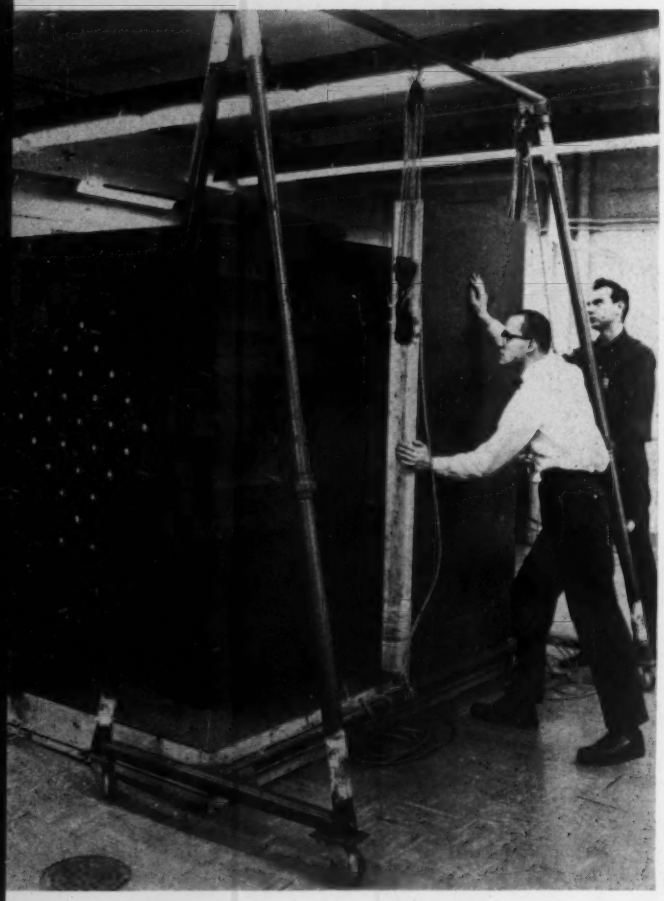
The lifting diaphragm, *produced by Domestic Film Products Corp. from 1/32-in. nylon, forms an airtight seal between top section of dome and ground, with air pumped through an underground tunnel. Air pressure is only 1.45-1.60 oz per sq in.*



Almost 1000 hexagonal steel panels *were welded together to form the structure. The panels average 15 ft in width and weigh a total of 560 tons. Vertices of adjoining panels are interlocked with 6-in.-dia steel pipe.*

■ Using only three basic steel forms—hexagonal panels, pipe and half spheres—Graver Tank & Mfg. Co., Div. of Union Tank Car Co., is fabricating the world's largest building without internal or external supports. The building, designed for use as a repair and maintenance facility for railroad tank cars, is as high as a ten-story office building and 110,000 sq ft in area. It is being constructed in Wood River, Ill. and will be named "Union Dome."

The unique method of fabricating this circular building—from the top down—is expected to result in cost savings over the similar Baton Rouge Dome which was built in the conventional manner in 1958 at a cost of $10 per sq ft. Advantages of the circular design include: low cost per square foot of area covered, visual control of working areas from one central point, and unimpeded materials and work flow.



Graphite:

Versatility Plus Key Properties Make it Suitable for Many Uses

Graphite is becoming increasingly popular as an engineering material, particularly in high temperature and nuclear work. These case histories were supplied by National Carbon Co., Div. of Union Carbide Corp.

Good nuclear properties

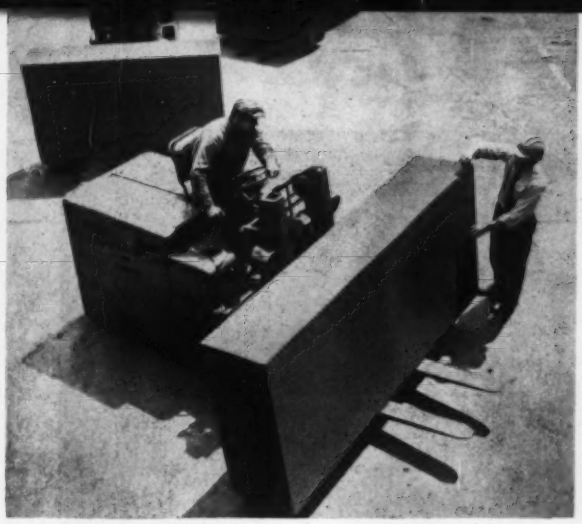
Shown here is a new Columbia University atomic reactor designed with a pile of 270 bars of high purity, nuclear-grade graphite. (Nuclear-grade graphite is specially processed to contain less than 1 ppm boron.) Each bar is 4 in. square by 60 in. long. Notches are cut into a predetermined number of the bars to allow insertion of aluminum tubes containing uranium-bearing fuel slugs. Neutrons are fed into the pile from the bottom layer of graphite bars, where a plutonium neutron source can be placed in various locations.

Also worth noting is the ingenious shielding slab, being installed. This slab consists of a 6-in thick layer of paraffin, 1 in. of which is impregnated with boron, which has a great affinity for neutrons. When the reactor is operated with the boronated layer on the outside, the neutrons emerging from the pile "see" only the paraffin, which acts as a mirror and reflects the neutrons back into the pile to increase the neutron multiplication factor. Contrarily, when the boronated surface is placed next to the pile, it acts as a "sponge" and absorbs neutrons leaving the pile. Thus, the pile is always fully shielded by boron for safety, yet can be operated either reflected or unreflected with ease.

Another advantage of the design is that the graphite assembly can be operated as a sigma pile without uranium fuel to study graphite's nuclear properties. The square graphite bars, which were previously sawn away to make the notches, are simply replaced so that a monolithic or solid graphite structure is approached.

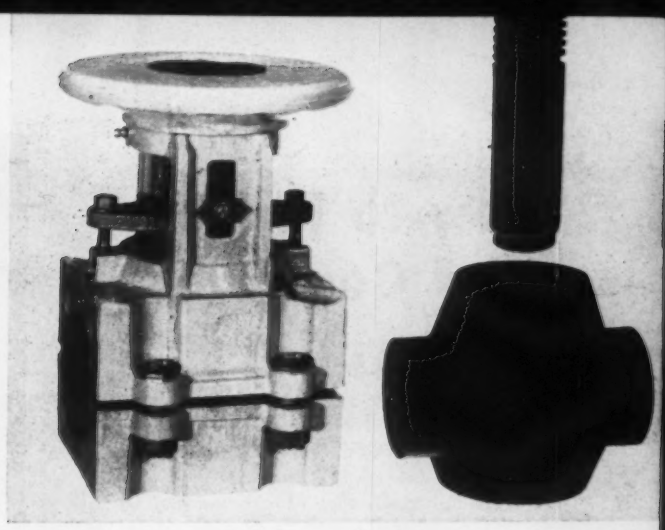
Heat resistant

This graphite rocket engine exhaust nozzle insert in the Lacrosse missile withstands a temperature change of 5000°F in a very short period. Graphite has proved to be one of the few materials suitable for such applications. In addition to its excellent high temperature properties, the material can be machined to precise tolerances. The inner throat section (shown being gaged) is machined to within ±6 mils, and the outer diameter is held to a total tolerance of 1 mil. The insert is manufactured by National Carbon Co. for Parish Pressed Steel (Div. of Dana Corp.), a subcontractor for Martin Co.



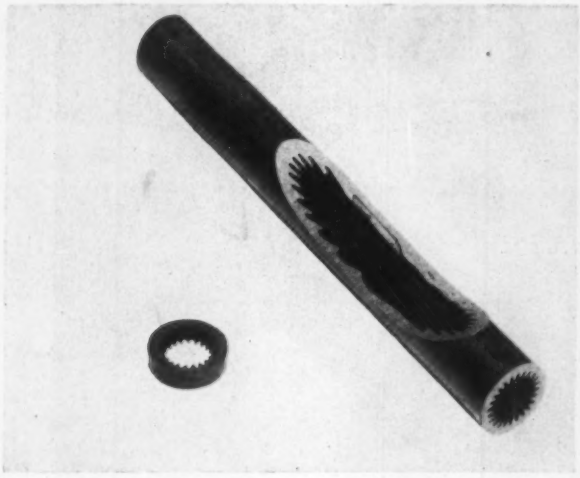
Dimensionally accurate and stable

The accuracy of stainless steel honeycomb panels for aircraft depends largely on the dimensional stability of these graphite brazing forms which are fabricated from the largest blocks of graphite ever made. Stainless steel skin surfaces are joined to honeycomb cores in high temperature brazing furnaces; because of its very low thermal expansion, graphite has proved to be the only material that could support the panels and hold their extremely accurate dimensions. In addition, the material can be precisely machined to the intricate shapes and contours required. The forms are now being produced in sizes up to 110 in. long and when joined together will permit the fabrication of honeycomb panels in sizes previously not obtainable (up to 10 by 20 ft).



Resistant to chemicals

Resistance to a wide range of corrosive chemicals, plus other important properties, were obtained by using impervious graphite for the spindle and globe in this new valve. The self-lubricating properties of the spindle cut maintenance and lengthen life. In addition, the strength and heat resistance of the graphite globe permit operation at a pressure of 100 psig and a temperature of 340 F. Cast iron body casings are used around the graphite parts to protect them from accidental damage. All metal parts are covered with a corrosion resistant epoxy coating.



High thermal conductivity

The combination of high thermal conductivity and fin construction provides high efficiency in this new graphite heat exchanger tube. Twenty-three fins, each 3/16 in. high, increase the heat transfer area to 2.6 times that of a plain ⅞-in. i.d. tube. Furthermore, the helical twist of the fins promotes turbulent flow and increases heat transfer as fluid velocities increase. Because of its extra surface area the operating heat flux and temperatures in the heat exchanger are reduced, permitting a longer operating cycle between cleanings, reducing maintenance costs.

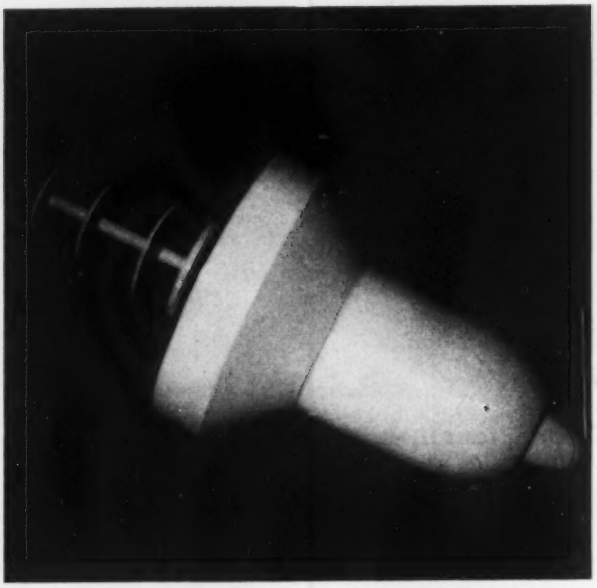
Available in large sizes

This 7-ton graphite cylinder is the largest ever made —61 in. in dia by 72 in. long. After coring, the cylinder will be used in a large graphite tower in which elemental phosphorous will be burned for the production of phosphoric acid.

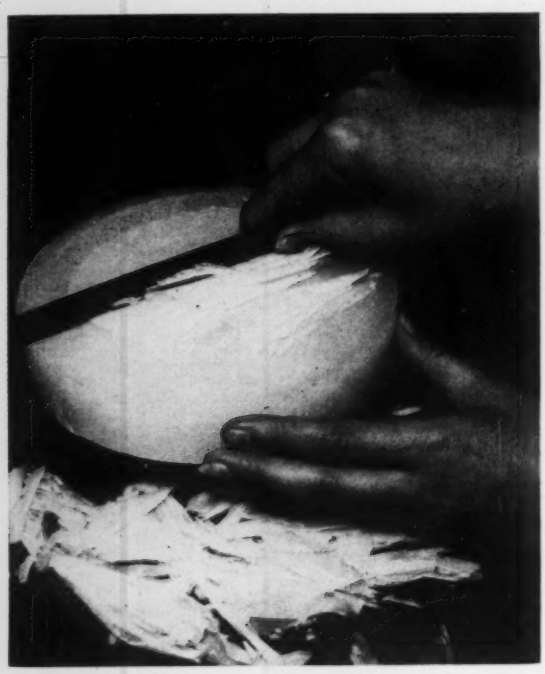
High temperature process equipment of essentially monolithic construction is made possible by the production of fine grained graphite in this unprecedented large size. Furthermore, the reduction in the number of joints in such a large size unit simplifies field erection and lowers maintenance costs.

How to Make Low Cost Models of Paraffin

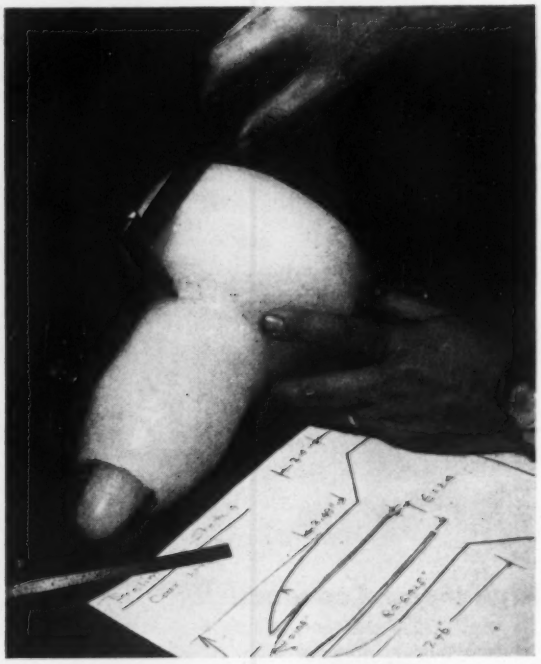
by Willis E. Junker and Robert J. Pritchard
Convair—San Diego, Div. of General Dynamics



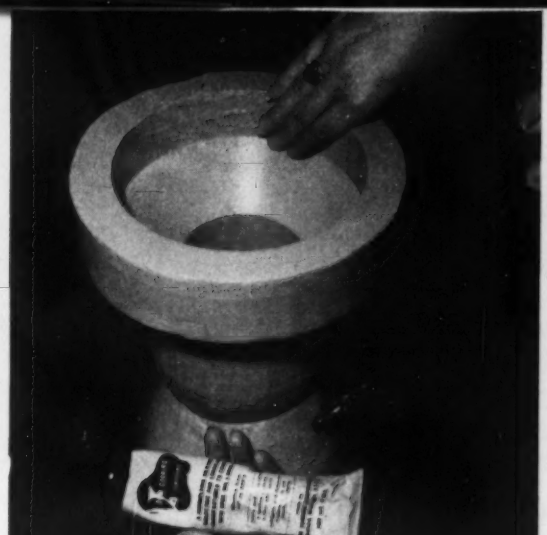
***Right**—Paraffin model of a broadband coaxial feed lens is an example of the complex shapes that can be produced simply and quickly from wax, eliminating the need for more costly materials and techniques. Large parts offer the biggest savings. Small parts may be easily deformed even by moderate handling. Any number of models may be cast by the method described on these two pages.*



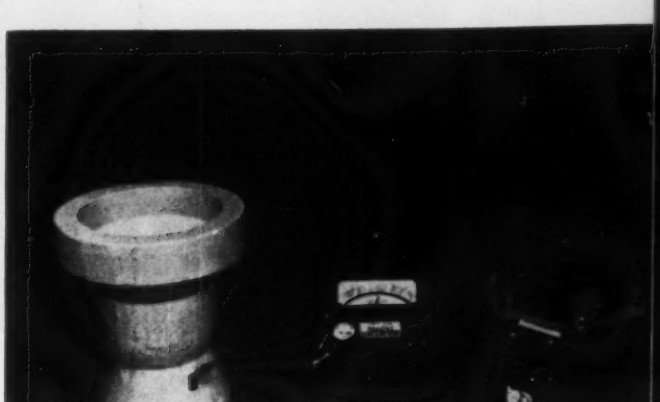
1 Carve prototype manually. *This hand carving may serve as the final model if only one is needed, or if the homogeneity of the paraffin is important. In this application, the dielectric properties of the model are to be determined, and internal structure is important. Therefore, this hand model (made with knife, straight-edge and simple lathe) will be used to make a plaster mold that will allow casting of uniform paraffin models.*



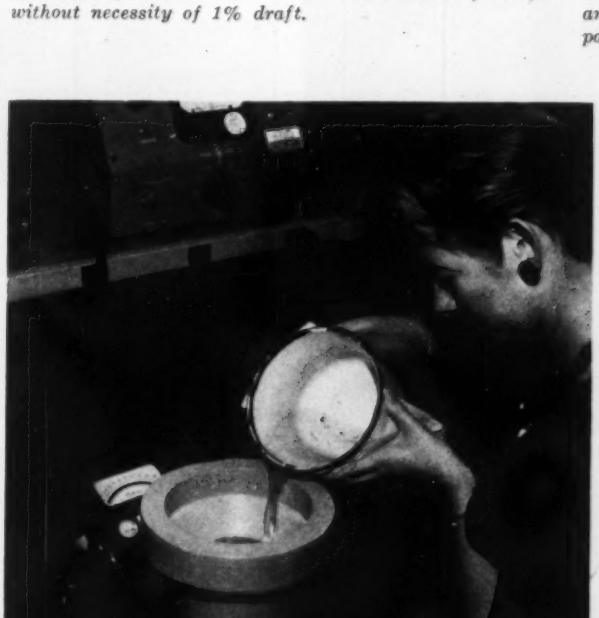
2 Check prototype dimensions. *The hand carved prototype must be checked against the dimensions of the original sketch before making the mold. This particular shape has no contours that undercut the vertical and will therefore require only a one-piece mold, effecting further savings. A series of alternative wax prototypes can be produced for less than the cost of a single model made in a more permanent plastics material such as Teflon.*



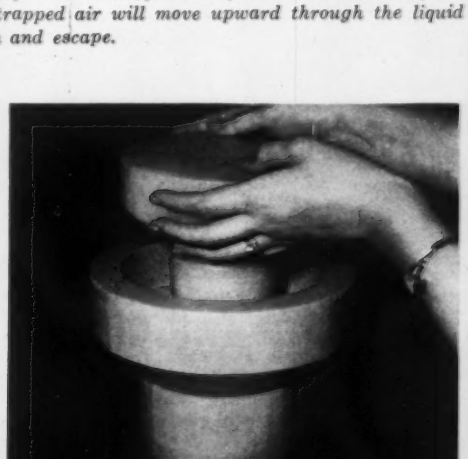
3 ***Make a plaster mold.*** *The mold is made of a low shrinkage plaster, such as Hydracol. To obtain homogeneous wax castings, provide for differential heating and cooling in the mold (see next photo). Apply a thin coat of silicone grease to the mold to allow removal of model without necessity of 1% draft.*



4 ***Preheat the greased mold.*** *Heating is accomplished by a nickel wire which was embedded ¼ in. from the inner surface of the mold during forming. The wire is in the form of a spiral which concentrates more turns at the top. The lower portion of the mold will cool first, and entrapped air will move upward through the liquid paraffin and escape.*



5 ***Pour molten paraffin.*** *After the mold has been preheated for 1 hr, pour in molten wax. When the air bubbles stop rising, cool the mold 24 hr at room temperature. Blowing cool air over the mold may result in fractures or distortions; cooling in a vacuum may trap air bubbles within the wax.*



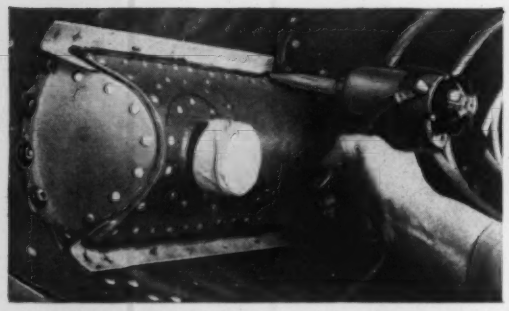
6 ***Remove the model.*** *Grease allows easy removal, yet its high melting point prevents contamination of the wax. Dimensions should now be checked.*

MORE MATERIALS AT WORK

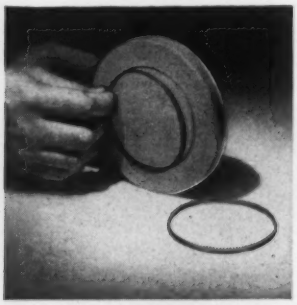
Flying platform skims water 151
Porcelain valves for corrosives 152
Missile powerplant uses forged aluminum 155
Epoxy-phenolic finish protects magnesium 156
Nylon gears: no contamination 156
Stainless castings 158

General Electric RTV silicone rubber

New liquid rubber cures without heat, useful from — 70 F to + 600 F, ideal for sealing, electrical insulation and flexible molds.

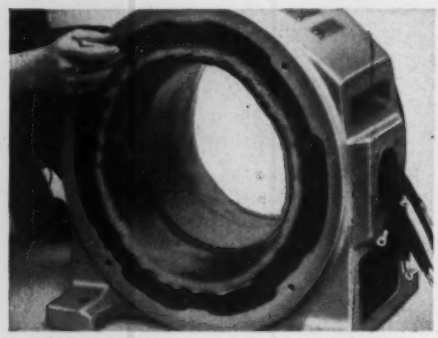


HEAT RESISTANT SEALING, such as shown on this Douglas DC-8 Jetliner, is made possible with RTV (room temperature vulcanizing) silicone rubber. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

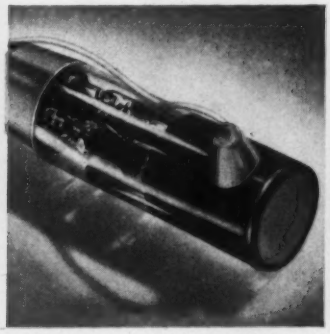


PRECISION MOLDING of prototype and engineering models and replacement parts is simplified and improved with RTV flexible mold material. G-E RTV's low shrinkage permits close tolerances and fine surface detail.

LOW-COST TOOLING with flexible RTV mold material offers added savings in time and expense. RTV's "built-in" release agent provides easy removal of this epoxy coil-winding form from mold. Total cost reduced 81%, delivery time 90%.



ENCAPSULATION OF STATOR WINDINGS, introduced by General Electric motor departments, extends service life of motors. RTV's resistance to moisture and other contaminants enables these dripproof motors to meet certain applications formerly requiring enclosed units.



POTTING OF AIRBORNE EQUIPMENT provides protection from high altitude arc-over and corona as well as vibration and moisture. RTV silicone rubber protects this cathode ray tube up to 70,000 feet.

RTV COIL IMPREGNATION enables this Hughes Aircraft Co. transformer to provide top performance at 250°. Unlike other insulations tried, G-E RTV compounds proved successful both for coil impregnation and full encapsulation.

For application data and samples of General Electric RTV silicone rubber write Section B-314, General Electric Company, Silicone Products Department, Waterford, New York

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 378

Special propeller *pumps large volume of air to lift platform about 2 ft above the water.*

Flying Platform Skims Water

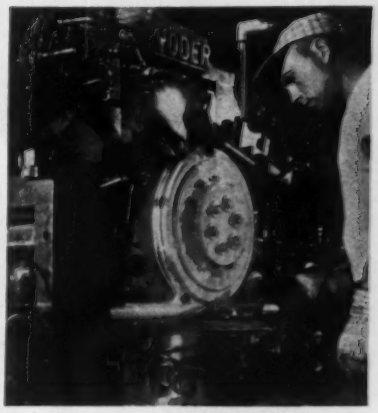
Aluminum extrusions and sheet, polystyrene foam, and a good deal of imagination have been successfully teamed in the first full-scale "flying platform"—a unique combination of ship and plane.

The platform, called a Hydro-Air vehicle, is a remarkable cargo-carrying craft designed to streak between ports at about 50 mph at a fraction of the power ordinarily required. Secret of the vehicle's efficiency is the virtual elimination of friction, the craft rides on a cushion of air about 2 ft over the water's surface.

Developed by Spacetronics, Inc., the tear-shaped vehicle is 32 ft long, 24 ft across at the widest point, and 2 ft high. A specially-designed fan in the bow rotates horizontally

Polystyrene foam *is packed into aluminum shell to provide buoyancy and strength.*

Aluminum sheet and extrusions *form center section of flying platform.*



Yoder Tube Mills speed tailpipe production at AP Parts Corporation

The AP Parts Corporation (Toledo, Ohio), world's largest producer of replacement mufflers and tailpipes, uses 2 YODER Tube Mills to produce more than *300* ft. of 1¾", 1⅞" and 2" tubing per minute.

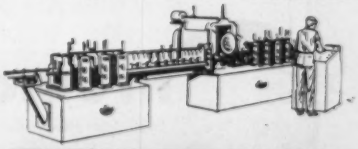
According to Mr. John Grindle, Plant Engineer, the two-man operated YODER Mills are vital to the production of the entire plant. "YODER Tube Mills earn their keep daily. They are easy to set up, maintain and operate ... the welds are clean and uniform. We depend on them for constant quality, high production and minimum downtime".

The YODER Tube Mills at AP Parts exemplify the production economies and dependability of all YODER-built equipment, whether it be Pipe and Tube Mills, Cold Roll-Forming Machinery or Slitting Equipment.

If your products require ferrous or non-ferrous pipe or tubing, from ¼" to 26" diameters, there is a YODER Mill designed to produce it economically, accurately and efficiently.

For complete information on YODER Pipe or Tube Mills ... write for the fully illustrated, 88 page YODER Tube Mill Book ... it is yours for the asking.

THE YODER COMPANY
5546 Walworth Avenue • Cleveland 1, Ohio



ENGINEERING YODER MANUFACTURING
PIPE AND TUBE MILLS
(ferrous or non ferrous)

For more information, circle No. 337

Roll Back The Thermal Barrier ....

with CHROMALLIZING

Oxidation and thermal shock resistance of metals used in jet engines and similar superheat applications are greatly improved with CHROMALLIZING. The patented and proven process of diffusing chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.

Ordinary steel can also be chromallized to provide resistance to corrosion, oxidation and wear.

A recent Chromalloy development, IOCHROME (99.997% pure chromium), is a basis for chromium alloys for use at 2500°F.

Write for illustrated BULLETIN MH

Chromalloy corporation

450 Tarrytown Road • White Plains, New York
WHite Plains 6-0020

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PROPELLEX CHEMICAL DIVISION, EDWARDSVILLE, ILLINOIS
Propellants, cartridge actuated devices, explosives and special chemicals.
ELYRIA FOUNDRY DIVISION, ELYRIA, OHIO. Quality gray iron castings.
SINTERCAST DIVISION, YONKERS, N. Y. Machinable carbides & nuclear materials.

For more information, turn to Reader Service card, circle No. 351

and pumps a huge volume of air between the platform and the surface of the water. Although the air pressure is quite low (only a few ounces per square inch), it provides enough upward push to lift the unit 2 ft. Forward propulsion is provided by aft-mounted fans. According to Spacetronics, the cushion of air that supplies the lift will not kick up a heavy spray.

Aluminum, supplied by Aluminum Co. of America, was selected because of its light weight and corrosion resistance. The polystyrene foam provides buoyancy and additional strength.

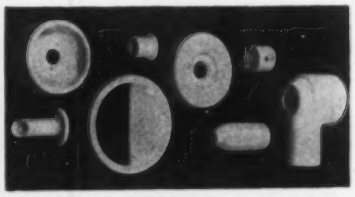
Porcelain Valves For Corrosive Liquids

Although initially developed primarily for high voltage electrical applications, vacuum process porcelain is becoming increasingly popular for valves, pipe, fittings, plugs and other parts used to handle corrosive liquids.

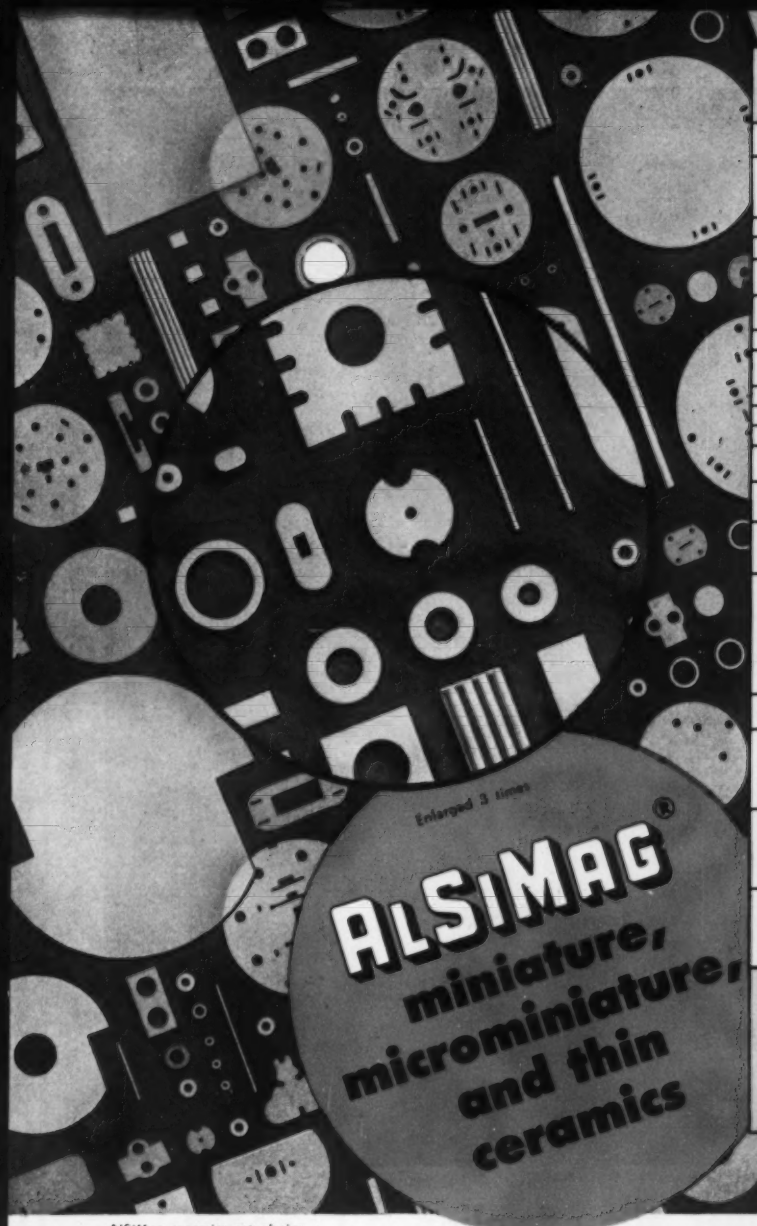
Primary advantages of porcelain are: 1) excellent resistance to all acids (except hydrofluoric); 2) ease of fabrication into special shapes; 3) resistance to high temperatures; and 4) noncontaminating characteristics. Other advantages are: zero absorption, low density, good tensile strength, low thermal expansion and high compressive strength.

The accompanying photo shows some of the various shapes and sizes of porcelain parts currently being made by Lapp Insulator Co., Inc. According to Lapp, the material used is a compound of plastic clay, kaolin, quartz and feldspar.

To produce parts, proper proportions of the compound are first added to water to produce a uniformly fine slurry. The slurry is placed in a



***Porcelain parts** used in chemical processing.*



AlSiMag ceramics actual size

Mechanical and Electrical Properties of AlSiMag Alumina Ceramics 393, 548, 614

PROPERTY		ALSIMAG 393	ALSIMAG 548	ALSIMAG 614
Water Absorption		12 to 18 Highly Porous	14 to 17 Highly Porous	0.00 Impervious
Specific Gravity		2.4	2.4	3.7
Density		.087	.087	0.135
Softening Temperature		1 800 3 272	2 050 3 722	1 650 3 002
Safe Temperature at Continuous Heat		1 400 2 552	1 600 2 912	1 550 2 822
Hardness		———	———	9
Thermal Expansion Linear Coefficient		6.0×10^{-6} 7.2×10^{-6}	6.9×10^{-6} 8.2×10^{-6}	6.5×10^{-6} 7.9×10^{-6}
Tensile Strength		———	———	25 000
Compressive Strength		30 000	10 500	400 000
Flexural Strength		10 000	8 000	60 000
Resistance to Impact (½" rod)		3.0	3.0	7.0
Thermal Conductivity (Approximate Values)		.004	.004	.045
Dielectric Strength (step 60 cycles) Test discs ¼" thick		50	50	230
Volume Resistivity at Various Temperatures	25°C.	$>10^{14}$	$>10^{14}$	$>10^{14}$
	100°C.	5.0×10^{12}	$>10^{14}$	2.0×10^{13}
	300°C.	1.0×10^{10}	$>10^{14}$	1.1×10^{10}
	500°C.	7.5×10^{7}	1.0×10^{10}	7.3×10^{7}
	700°C.	3.6×10^{6}	2.7×10^{8}	3.5×10^{6}
	900°C.	5.6×10^{5}	8.0×10^{6}	6.8×10^{5}
Te Value		835 1 535	1 000 1 832	840 1 544
Dielectric Constant	60 Cycles	———	———	———
	1 MC.	5.5	5.5	9.3
	100 MC.	5.3	———	———
	10,000 MC.	———	———	9.1
Power Factor	60 Cycles	———	———	———
	1 MC.	.0005	.0005	.0003
	100 MC.	.0005	———	———
	10,000 MC.	———	———	.0014
Loss Factor	60 Cycles	———	———	———
	1 MC.	.003	.003	.0028
	100 MC.	.003	———	———
	10,000 MC.	———	———	.013

These are the most frequently used AlSiMag ceramic compositions for small or thin designs.

Other AlSiMag formulations are available to meet highly specialized requirements. For advice on such requirements give operating details.

AlSiMag pioneered the custom manufacture of ceramics for modules and for micromodules and has long been known for its leadership in precision ceramics in small sizes and thin cross sections. Long experience has helped produce miniature and sub-miniature ceramics to tolerances generally associated with fine metal work.

Uniformity of material and dimension is necessary to reach goals of micro-miniaturization.

AlSiMag ceramics are playing their part in increasing reliability of these components and in greatly reducing sizes of sub-miniature electronic components.

Even the close tolerances required in vacuum tube insulators and spacers are maintained in these AlSiMag microminiature ceramics without grinding. Tubes with walls as thin as .010" and flat shapes as thin as .005" are produced regularly.

These precision ceramics are widely used as electron tube components . . . supports, spacers, envelopes, windows . . .and as micromodule wafers, transistor bases, relay components, etc.

See Booth No. 4502 at I.R.E. March 21-24.

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AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENN.
58TH YEAR OF CERAMIC LEADERSHIP

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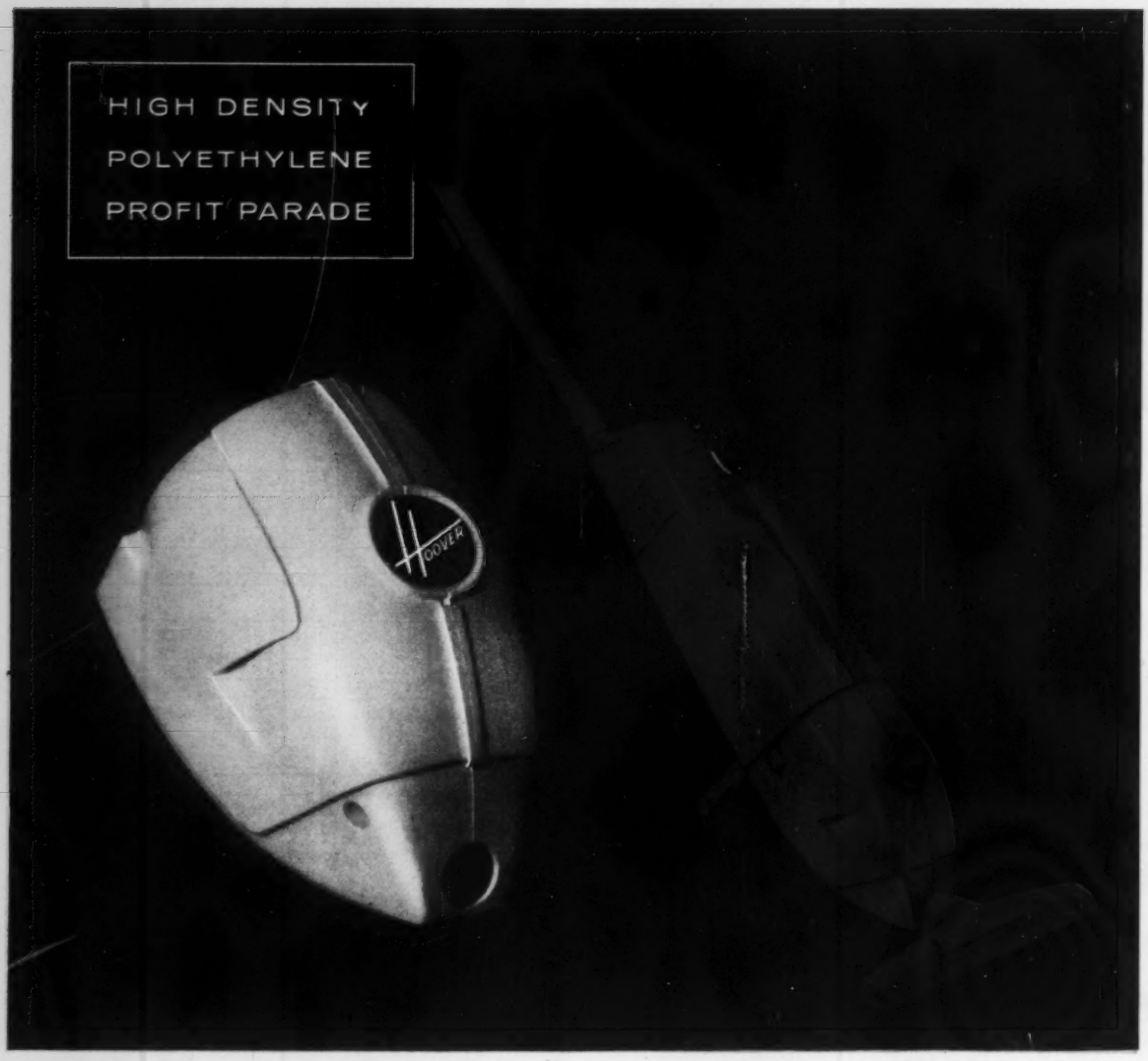
For more information, turn to Reader Service card, circle No. 430



Grace Plastic Goes into New Appliance Concept

Are you working on a "new concept" product? High density polyethylene from Grace could provide a better answer to your product's unique requirements than any other raw material. The Hoover Company reached just such a conclusion in screening plastics for the motor housing of their new home appliance concept—an electric floor washer that cleans with its own detergent solution and dries by vacuum action.

Why did Hoover select Grex high density polyethylene? The motor housing has to be unaffected by moisture and the chemicals with which it comes in contact. It must withstand heat generated by the motor and possess high impact strength. Its color—a primrose yellow—has to be an exact match of the other parts. Just as important, the housing must be light in weight, economical to produce and flame retardant.

By specifying Grex, Hoover obtained the motor housing they needed. Although the requirements for your new product may not be the same as Hoover's, bear in mind that this Grace plastic offers many remarkable properties still waiting to be exploited.

Find out more about high density polyethylene by calling in the experts. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION
CLIFTON, NEW JERSEY

For more information, turn to Reader Service card, circle No. 457

Hoover motor housing points up considerations in designing for Grex.

Designing superior parts with high density polyethylene requires knowledge of molding and mold design techniques and the inherent characteristics of the material. A few considerations that went into the motor housing of Hoover's new electric floor washer may be helpful in your own designing for Grex.

Color match. High density polyethylene flame retardant compounds, compared to natural high density polyethylene, are much more opaque white and therefore more difficult to color match. However, it is usually easier to obtain a color match with flame retardant Grex than with any other flame retardant plastic comparable in both cost and performance. In this case, a flame retardant compound was specified for the motor housing. The material was satisfactorily compounded to match a primrose yellow used for other parts of the appliance.

Section thickness. The original mold design for this housing incorporated heavy sections and variations in wall thickness which had to be corrected before actual production. These are to be avoided wherever possible as a cause of differential shrinkage or part distortion. As an added consideration, thinner wall sections result in economies in material and, with proper molding techniques, usually give a faster cycle.

Call us for help. If you are now working on a design for high density polyethylene—or are just thinking about some new project—remember that Grace is ready and willing to provide technical assistance. Bring us into your picture any time—the sooner the better.

Technical Service Department
W. R. Grace & Co., Clifton, N. J.

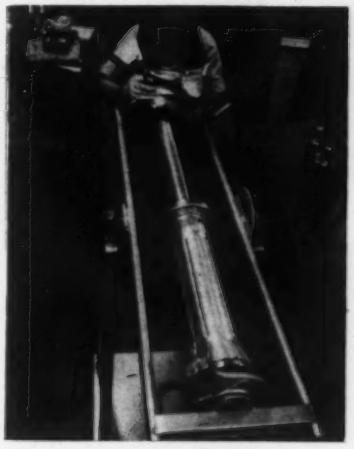
MATERIALS AT WORK

vacuum chamber where air is boiled out. The resulting clay is pressed into flat cakes and extruded into a fine-grained plastic body which can be formed by turning, plunging, jiggering or throwing. Complex parts, such as valve bodies and pipe fittings, are cast directly from the liquid clay.

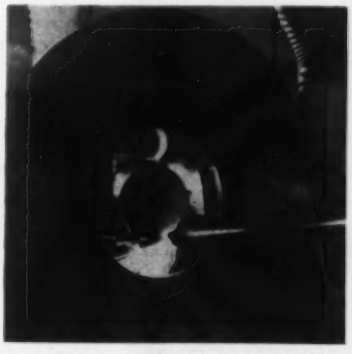
Missile Powerplant Uses Forged Aluminum

Rocket engines for the Navy's Sparrow and Bullpup guided missiles are being fabricated from forged and machined 6066 aluminum alloy, it has recently been revealed.

According to Reaction Motors



***Stainless steel** deflector is welded to aluminum combustion chamber.*



***Ceramic coating** is flame sprayed on interior surface of combustion chamber and exit cone to protect aluminum from high temperatures.*

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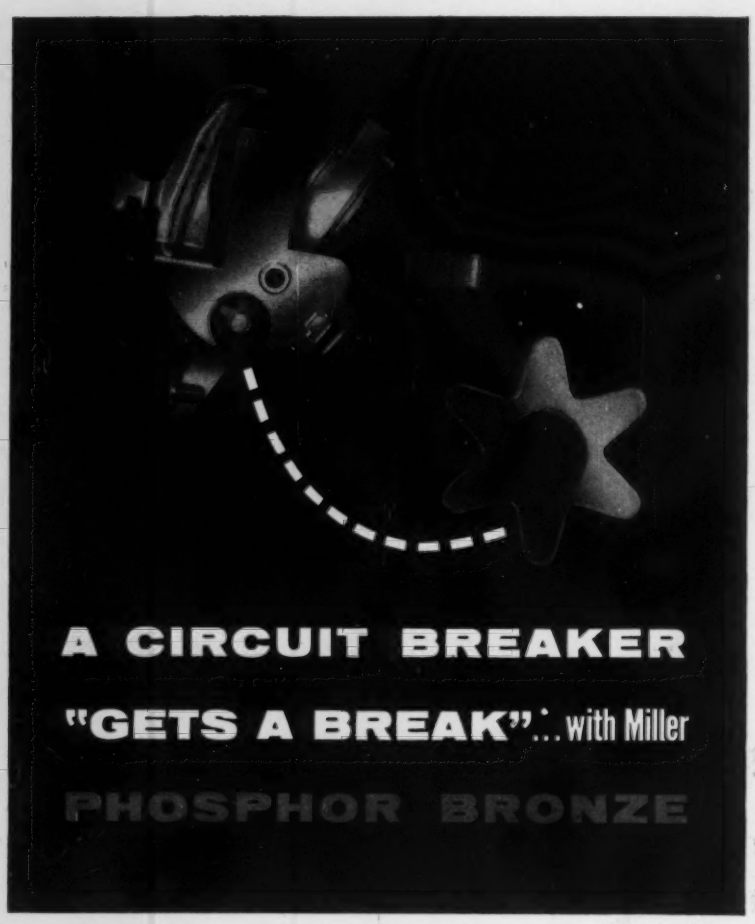

Design engineers for a leading manufacturer of circuit breakers specified phosphor bronze in the star spring of the circuit breaker shown here. Ordinary phosphor bronze was used, but spring pressure wasn't uniform, and breakers often failed to open under an electrical overload.

Miller—whose specialty is phosphor bronze—experimented with various alloys and tempers for the phosphor bronze spring until they came up with the right material for the job. They specified Miller Grade A Phosphor Bronze—a material that met the rigid requirements for the job . . . was highly corrosion-resistant . . . and was *less* expensive than the phosphor bronze originally used!

Only specialists in phosphor bronze like Miller can get to the bottom of your application problems so quickly.

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Div., Thiokol Chemical Corp., aluminum was selected for the major components of the rocket engines because it is lightweight and easy to work.

Epoxy-Phenolic Finish Protects Magnesium

Thanks to an epoxy-phenolic protective coating, Sikorsky Helicopter Co. has been able to combine magnesium and steel to reduce weight and increase strength of a component used in helicopter rotor assemblies.

The component consists of a circular magnesium collar into which steel inserts are placed to provide added toughness and strength. Since the magnesium parts must be insulated against direct contact with the steel (to prevent electrolytic action), the cadmium-plated steel inserts are coated at contact points.

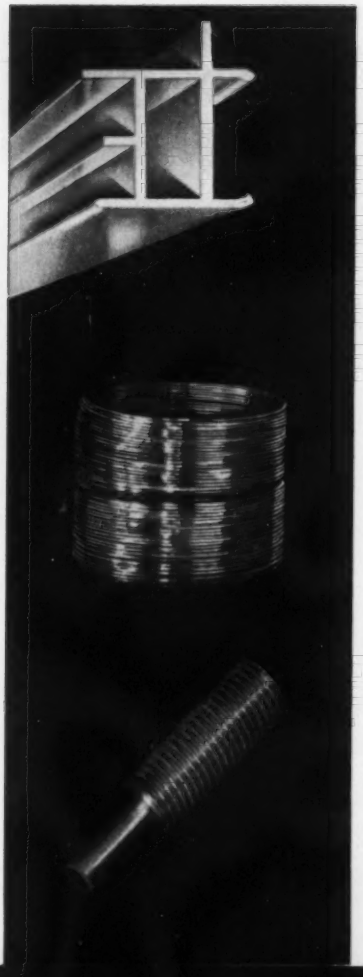
According to Midland Industrial Finishes Co., the epoxy-phenolic coating not only effectively insulates the magnesium against electrolytic corrosion, but also provides excellent resistance to corrosion from condensation.

Machined Nylon Gears Prevent Contamination

The change from steel to nylon has eliminated a major problem in the design of gears in a machine used to cut polyethylene sheet and ribbon stock into cubes and rectangular pellets.

According to Spencer Chemical Co., the problem was one of product contamination caused by lubricants used on the steel gears. Nylon was selected primarily because it is self-lubricating and thus eliminates the need for contaminating lubricants.

Two other advantages, one of which derives from what would normally be considered a shortcoming, were also realized: 1) the nylon gears can be machined at about one-third the cost of steel gears, and 2) because nylon possesses a much lower shear strength than steel, any strain caused by a frozen bearing will shear off a portion of the nylon gear teeth instead of causing considerable dam-



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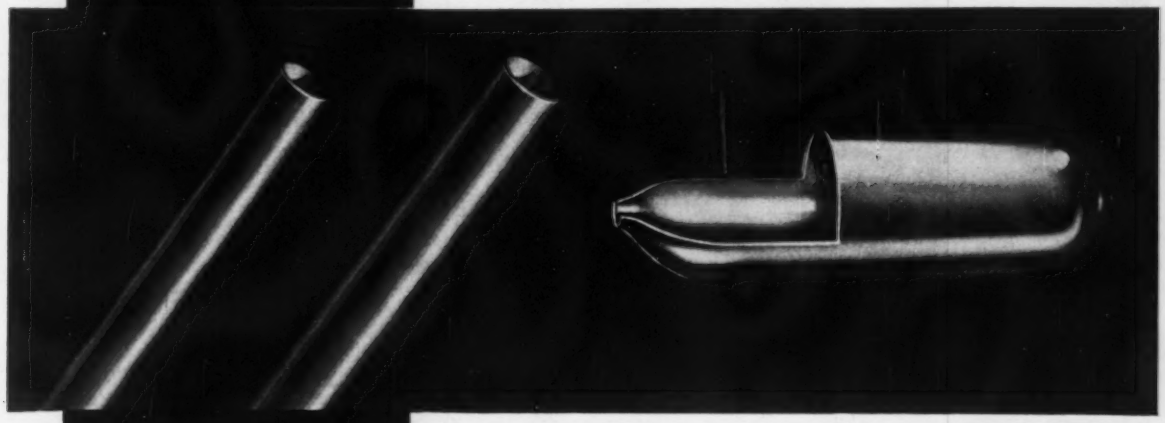
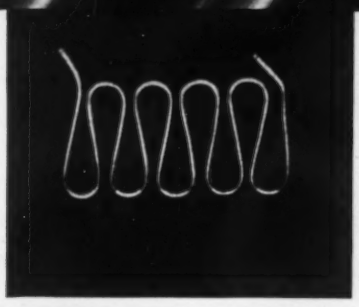
You can, for example, specify Wolverine in both drawn or extruded aluminum tube in prime surface form or with integral fins, in straight lengths, or in time saving long-length, bunch-type coils. If your requirements call for extruded aluminum shapes, Wolverine produces them to customer specifications. To insure its customers of complete aluminum service, Wolverine also maintains extensive spinning and fabrication facilities.

Wolverine's Aluminum Tube Catalog tells the complete story—is in addition, chuck-full of helpful information about this modern metal. Write for your free copy—TODAY.





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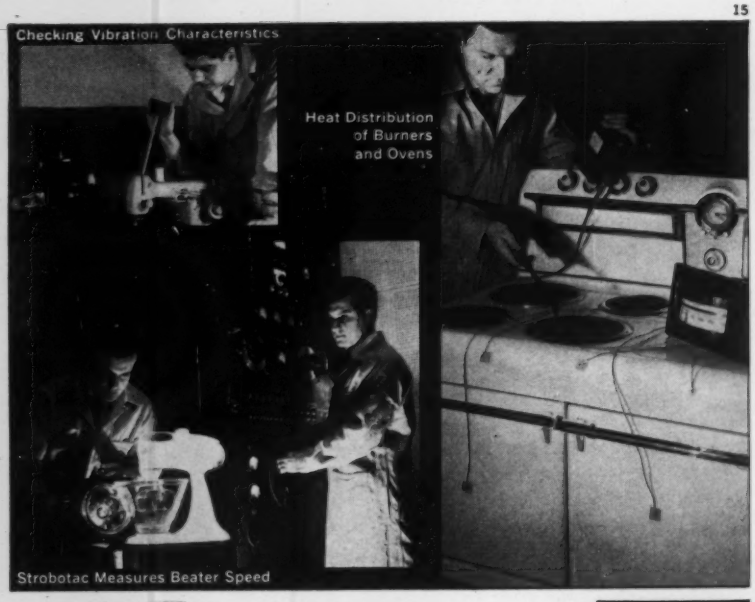

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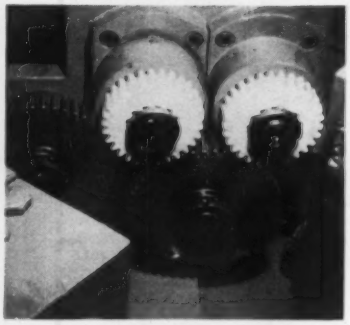
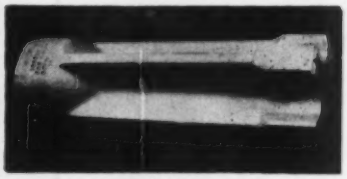
MATERIALS AT WORK



***Self-lubricating nylon gears** eliminate problem of contamination.*

age to the entire assembly.

As shown in the accompanying photo, nylon and steel gears are alternated. There are two reasons why this arrangement was specified in preference to a nylon-to-nylon arrangement: 1) to aid heat conduction because the enclosed gear assembly is not adequately ventilated and nylon has a low thermal conductivity (in relation to steel), and 2) because it is less expensive to replace alternate gears.



Stainless castings—Shown above is one of the 42 cast stainless control rod guides to be used in Consolidated Edison Co.'s Indian Point atomic power plant. The casting weighs about 180 lb and measures 38 in. long and 11 in. across the cruciform opening at the right. According to the Alloy Casting Institute, stainless castings were selected because 1) they provide the required combination of strength and resistance to heat and corrosion; 2) they can be produced more economically than welded assemblies or forgings; and 3) they can be easily designed with generous fillets and radii to eliminate crevices and possible entrapment of radioactive particles.

Tool Steel Topics

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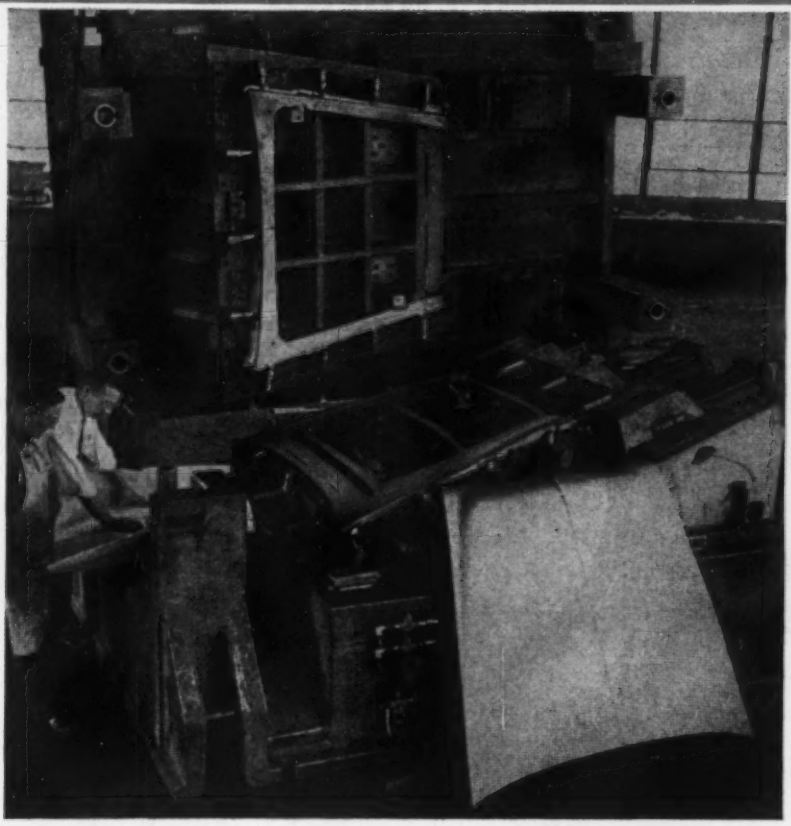
Export Distributor: Bethlehem Steel Export Corporation



Automotive Die, in 101 Sections, Made from Water-Hardening Steel

This huge die, made up of Bethlehem water-hardening tool steel (SAE W-2), trims an automobile hood. Made from tool steel furnished by Peninsular Steel Co., Detroit, the die was photographed recently at Republic Die & Tool Company, Wayne, Mich. It contains 44 composite sections, 34 wear plates, and 23 solid sections.

Bethlehem water-hardening steels were selected for this exacting application because of their good wear-resistance, easy machinability, and simple heat-treatment—plus ease of welding should repair become necessary.

Bethlehem water-hardening tool steels, because of their carefully controlled hardenability, provide economical service in applications calling for high shock-resistance. And with their highly selective carbon range, they have good resistance to wear, plus the toughness to withstand cold battering.

If you have any questions about the use of Bethlehem water-hardening tool steel, or any of our other popular grades, get in touch with your Bethlehem tool steel distributor. He's as near as your telephone.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Here's How to Stabilize Gages

High-precision gages, commonly made of BTR tool steel (AISI Type 01), need a stabilization treatment if they are to maintain their accuracy for years. Otherwise expansion will eventually change dimensions outside of the permissible tolerance. These dimensional changes are in a magnitude of hundred-thousandths of an inch per inch, or smaller. Insignificant on ordinary tooling, they are important on precision gages.

The expansion which occurs over a period of time is due to the transformation of austenite retained during the quench for hardening. The object of the stabilization treatments is to transform the retained austenite during the treatment, so that none remains which could transform later on. This condition exists in all tool steel grades which can be hardened to Rockwell C 60 or higher.

The most common method for stabilizing high-precision BTR gages is: 1. Quench and temper in the normal manner to produce the desired hardness. 2. Rough grind. 3. Subzero cool to minus 100/120 F in refrigerator or dry ice. 4. Warm to room temperature and then retemper at original temperature. 5. Finish grind to size. 6. Repeat cycles of subzero cool followed by tempering five more times. 7. Lap or superfinish to size.

Sometimes it is possible to shorten this procedure, particularly if the design is such that there is little hazard of cracking. For example, the tools can be subzero cooled directly from the quench, with no interval at room temperature, followed by tempering and grinding. This will permit stabilization with only two additional cycles of subzero cool plus temper, but the disadvantage is that cracking may occur after quenching.

It is also possible to shorten the stabilization by cooling to minus 314 F in liquid air. This permits reducing the cycles of subzero cool plus temper to three instead of six.

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If you are not now pre-coating or using pre-coated metals, it will pay you to investigate the production savings this process may offer. And if you are using pre-coating or pre-coated materials, it will pay you to investigate the additional advantages that SUPERCLAD or KEMCLAD may offer. The Sherwin-Williams Company, General Industrial Division, Cleveland 1, Ohio.

SHERWIN-WILLIAMS / INDUSTRIAL FINISHES

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New Prefixes for Units Adopted by NBS

The National Bureau of Standards has accepted the recommendations of the International Committee on Weights and Measures, adopting the following new prefixes for denoting multiples and sub-multiples of units:

Unit	Prefix	Sym	Pron.
10^{12}	tera	T	tĕr′a
10^{9}	giga	G	jĭ′ga
10^{-9}	nano	n	nā′nō
10^{-12}	pico	p	pī′cō

Other prefixes now in use by NBS are: mega (10^{6}, M); kilo (10^{3}, k); hecto (10^{2}, h); deka (10, dk); deci (10^{-1}, d); centi (10^{-2}, c); milli (10^{-3}, m); and micro (10^{-6}, μ).

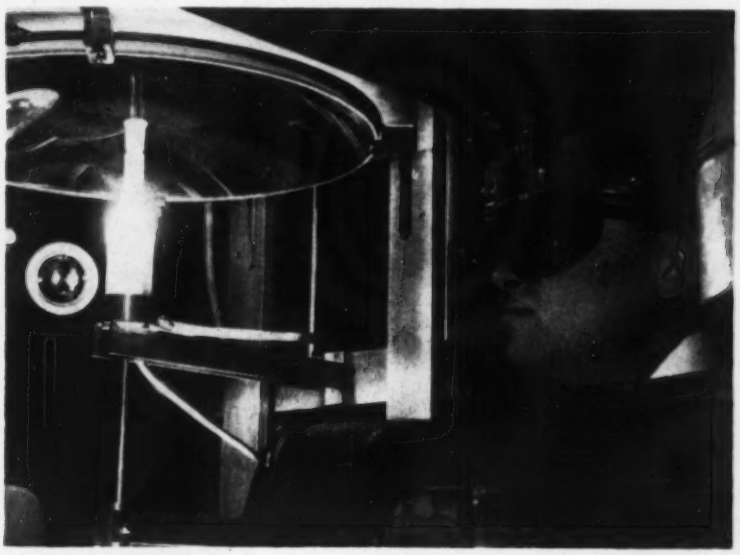
Entire Steel Industry Adopts Broad Identification Program

With the adoption of the Steelmark—an insignia designed to identify products made from steel—the steel industry hopes to eliminate possible confusion in the minds of consumers.

According to the American Iron and Steel Institute, this is the first time that the industry as a whole has combined forces to merchandise steel and steel products at the consumer level. The insignia—three differently colored hypocycloids and the word "steel" contained within a circle—will be attached to all steel consumer products including air conditioners, appliances, bed springs, furniture, hardware, jewelry, wheelbarrows, etc.

". . . We want to be sure," said Mr. Benjamin F. Fairless, AISI president, "that the American consumer has the correct modern image of steel in his mind . . . Products of steel can be light, modern and outstandingly stylish."

The adoption of the symbol is said to be the outgrowth of a nationwide study that revealed that although steel is synonymous with quality in the minds of the public, people frequently do not recognize products as being made of steel. The program will be spearheaded initially by basic steel producers through advertising, sales and merchandising efforts.



Pure refractory compounds—Shown here is an arc-image furnace used by scientists at Stanford Research Institute, Menlo Park, Calif. for growing crystals of carbides, nitrides and intermetallic compounds. The furnace has two "face-to-face" arcs separated by a 45-deg control mirror that can be rotated to divert light from either of the arcs to a vertical elliptical mirror. The vertical mirror focuses energy on top of the growing crystal.

Improved Materials Key to Future Progress

The growing awareness of the direct relationship between progress and advances in materials was re-emphasized at ASTM's recent Pacific Area National Meeting.

According to Frank L. Laque, ASTM president, "Everyone can instantly bring to mind some scientific or engineering development that has been, or still is, dependent on improvements in materials."

To illustrate, Mr. Laque said that "Further advances in the economical generation of power from nuclear sources will be determined more by improvements in materials and in the way they are used than by any solution in the realm of atomic physics. The extent to which man will be able to journey into space and especially to return

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News of Industry

safely," he continued, "will be controlled principally by the solutions to materials problems."

Other topics of interest discussed at the meeting: extreme environments which materials are now required to withstand in an age of rockets, jets, missiles, re-entry cones, atomic power plants and high temperature industrial processes; materials problems in our nation's airports, highways, dams, industrial plants, homes and waterfront structures; radiation spectroscopy as an analytical tool; utilization and disposal of industrial water; and air pollution control.

Space Flight Materials Subject of ASM Meeting

Materials problems in space flight systems will be the subject of a special two-day symposium sponsored by the Cincinnati, Dayton and Columbus Chapters of the American Society for Metals.

The symposium, scheduled for Apr 27-28 in Cincinnati, will consist of four sessions: 1) Space Flight—Its Unique Demands on

Design Show

Reminder: the 5th annual Design Engineering Conference and Show will be held May 23-26 at the New York Coliseum.

This year's conference, sponsored by the Machine Design Div., American Society of Mechanical Engineers, will cover latest developments in materials for extreme environments, new welding processes, explosive forming, high strength steels and composite materials.

The Show, sponsored by Clapp & Poliak, Inc., will feature displays of the latest metals, nonmetallics, fasteners and adhesives, finishes and coatings, and shapes and forms.

For complete details on registration, technical program and exhibitors, see the May issue of M/DE.

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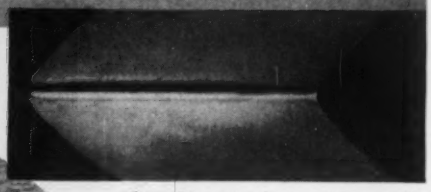
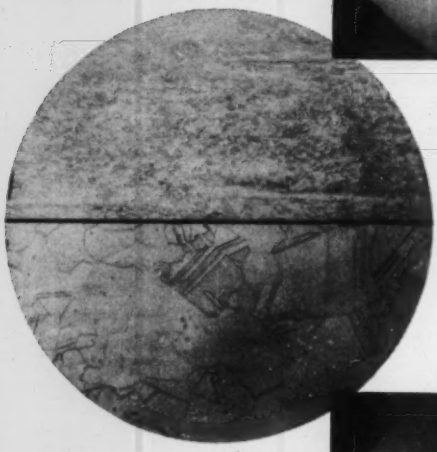
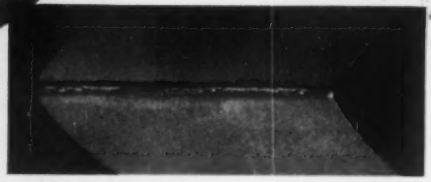




▲ Upper photomicrograph shows the fine even, grain structure resulting from WRM *precision annealing*. This structure gives the metal up to 30% greater fatigue life plus the increased formability that enables it to take the strain of severe bends as shown above.

ORDINARY ANNEALED SPRING TEMPER PHOSPHOR BRONZE ▶



▲ Lower photomicrograph shows coarse uneven grain that causes the type of cracking shown here.

For more information on WRM precision annealed phosphor bronze send for this new, free bulletin.

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News OF INDUSTRY

Materials; 2) Materials for Space Vehicle Launching Systems; 3) Materials for Vehicles in Space Flight; and 4) Materials for Atmospheric Re-Entry Systems.

For additional information, contact R. C. Downey, Bldg. 200, Rm. 207, General Electric Co., Cincinnati 15, Ohio.

Engineers

Clarence B. Campbell, chief engineer of the Steam Div., Westinghouse Electric Corp., has been awarded the Gold Medal of the Newcomen Society in North America "in consideration of his many outstanding achievements in the utilization of steam for the benefit of mankind."

Dr. Augustus B. Kinzel, Union Carbide Corp., is the recipient of the James Douglas Gold Medal, awarded by the American Institute of Mining, Metallurgical and Petroleum Engineers.

George J. Huebner, Chrysler Corp., has received the Buckendale Award from the Society of Automotive Engineers.

C. Robert Stone has been appointed chief production engineer, Potter & Brumfield.

H. W. Bevanly has been named manager of mechanical research and development, Girdler Process Equipment Div., Chemetron Corp.

George H. Lockwood has been named manager of development and research, Heald Machine Co.

Robert C. Allen has joined the applications engineering staff of McCormick Selph Asso.

Dr. D. Gardner Foulke is now research director, Precious Metal Div., Sel-Rex Corp.

John W. Hawley has been appointed manager, Product Development Dept., Chemtrol.

William H. Schweikert has been named technical director, Precision Castparts Corp.

Owen T. Gribbin has been appointed chief food chemist, Foster D. Snell, Inc.

D. A. Young has been named chief design engineer, Engineering Science Div., American Metal Products Co.

J. E. Brister has been appointed to the newly created position of co-

New ideas in NYLON

W. R. Sauey (left), president of Flambeau Plastics Corporation, Baraboo, Wisc., and Joe V. Graber, president of Graber Manufacturing Co., Inc., Middleton, Wisc., examine the new drapery hardware parts which Flambeau helped develop for Graber. Tough and quiet-operating, the new parts are molded from Spencer Nylon.

Spencer Nylon Parts In Drapery Hardware Give More Strength, More Quiet Operation

Flambeau Plastics Corp. develops tough, lightweight Spencer Nylon parts for Graber Manufacturing Company's new drapery hardware.

Gears and other moving parts in drapery hardware should have two important properties.

First they should be strong. During operation, they are often subjected to grating friction.

Second, they should operate quietly. Nearly every housewife is distressed by squealing and screeching when drapes are opened or drawn.

Until recently, few materials offered these two important properties. But now, tough and quiet-operating drapery hardware parts are available at a new low cost.

Molded of Spencer Nylon, these new parts were developed by Flambeau Plastics Corporation, Baraboo, Wisc., in conjunction with Graber Manufacturing Co., leading manufacturer of quality drapery hardware.

So strong are these new Spencer Nylon parts, that they actually outwear many comparable metal parts. Yet, they are conveniently lightweight—up to one-half the weight of comparable metal parts.

Virtually silent operation is allowed by the new Spencer Nylon drapery hardware parts. They may be produced in quantity at big savings over comparable metal parts.

A processing advantage of Spencer Nylon is its special "body" which makes it suitable for complicated shape extrusions. Also, Spencer Nylon has less water than other type nylons which means no costly drying time is necessary.

As a leading supplier of nylon for all types of molding and extruding applications, Spencer has the experience and personnel that can help you. For information, contact Spencer Chemical Company at the address below.

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SPENCER NYLON

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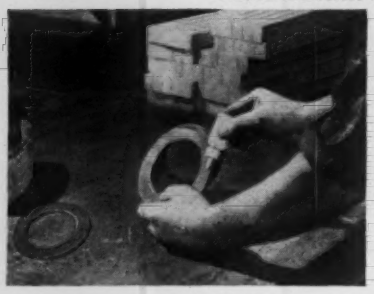
No. 11 of a series



Eastman 910 Adhesive solves another production bottleneck

The Refractories Division of The Carborundum Company, Keasby, New Jersey, uses fast-setting Eastman 910 Adhesive to tack steel facings to hardwood refractory molds.

By eliminating the need for complex clamps, the new technique has simplified the assembly of molds having angled surfaces, speeded production, reduced costs.

Several drops of the unique adhesive are applied to the surface of the wooden mold, and the steel face is hand held in position for several moments.

Within minutes, the bond is strong enough to permit drilling through the steel face and the mold preparatory to screw fastening.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9103 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. E-3, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

For more information, circle No. 375

News OF INDUSTRY

ordinator—defense materials, Union Carbide Plastics Co., a division of Union Carbide Corp.

Louis Polk, Jr., has been named assistant vice president and manager, Gaging and Automation Systems Divisions, Sheffield Corp., a subsidiary of Bendix Aviation Corp.

Dr. Donald S. Arnold has been named manager of research at American Potash & Chemical Corp.'s Trona, Calif. plant.

Companies

Polymer Corp., Reading, Pa., has formed two new divisions: Whirlclad Div. and Molding Resins Div.

Detroit Gray Iron & Steel Foundries, Inc., will establish a Shaw Process Div., operating under a license from Shaw Process Div. of British Industries Corp.

E. I. du Pont de Nemours & Co., Inc. has awarded more than $1,300,000 to 143 universities and colleges as part of the company's annual program of aid to education.

Air Accessories, Inc. plans to build a new branch factory at 115 E. Brackenridge St., Fort Wayne, Ind.

Timken Roller Bearing Co. has acquired the assets of **British Timken Ltd.**

H. K. Porter Co., Inc. has acquired Hill Transformer Corp., San Carlos, Calif.

Reynolds Metals Co. has begun production in its new plastics plant in Grottoes, Va.

Chrysler Corp. plans to construct a multi-million-dollar plant in Dewitt, N. Y., for its New Process Gear Div.

Diamond National Corp. is the new name for **Diamond Gardner Corp.,** Stamford, Conn.

Dorr Consultants, 99 Park Ave., New York City, is a new firm of consulting engineers which will offer services to the chemical process, textile and metallurgical industries.

Fawick Corp. has established a new Hydraulic-Electronic Div., with Ray G. Holt as manager.

Wheelabrator Corp. has purchased **Lake Erie Machinery Corp.** of Buffalo, N. Y., which will be operated as a wholly-owned subsidiary.

L-R Heat Treating Co. and **Ace Metal Treating Corp.** have merged to form **L-R Metal Treating Corp.,**

ASARCO

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Immediately available from stock: **ASARCON 773 BEARING BRONZE** (SAE 660)—260 sizes of rods and tubes. Complete range of sizes from ½" to 9" diameters. Immediately available from stock in 105" lengths. Special shapes produced to order.

Note minimum clean-up necessary between casting of this 6-tooth pump impeller and finished part. (Illustrated parts are 4" in diameter.)

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

CONTINUOUS CAST DEPARTMENT

West Coast Distributor: Kingwell Bros., Ltd., 457 Minna Street, San Francisco, Calif. In Canada. Federated Metals Canada, Ltd., Toronto and Montréal. Distributors in many principal cities.

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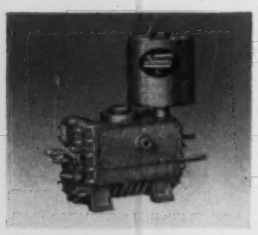
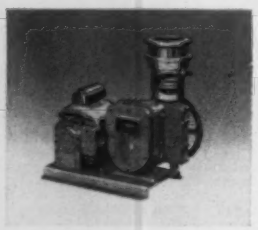
The urgency for more information—faster—places a higher burden than ever on research facilities and personnel. KINNEY, pioneers in High Vacuum, are abreast of today's and tomorrow's needs in advanced design High Vacuum Equipment for the Laboratory, Pilot Plant or full Production.



SINGLE STAGE PUMPS

The famous KINNEY Rotary Piston Mechanical Pump, producing pressures to 10 microns. The broadest selection in the world—thirteen sizes from: 13 cfm to 850 cfm free air displacement . . . every Pump test-run to exceed rated performance.

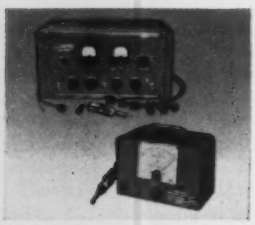
Bulletin 3120.1



TWO STAGE PUMPS

Attaining ultimate pressures in the order of .2 micron, KINNEY Two Stage Mechanical Pumps offer special advantages in speed of pump down, low cost operation and freedom from maintenance. Six sizes: from 2 cfm to 46 cfm free air displacement.

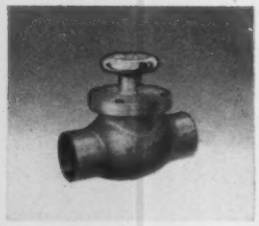
Bulletin 3150.1



VACUUM GAGES

Cabinet and Panel mounted Gages to provide new standards of accuracy in ranges of 1 to 3000 microns and 3000 microns to 10^{-7} mm Hg. The famous Series GCT Compensated Thermocouple Gage which eliminates need for matching tubes and the new Series GICT Ionization-Thermocouple Gage.

Bulletin 3800.1
Bulletin 3811.1



VACUUM VALVES

A new series of Sweat Fitted Bronze Bellows Valves is now available in the comprehensive KINNEY Line of Vacuum Valves. Featuring a design that permits replacement of bellows without disturbing installation, these new Valves are available in 1", 1½", 2" and 3" sizes.

Bulletin 3421.1A

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For more information, turn to Reader Service card, circle No. 368

News of Industry

with main plant and offices at 107-11 Vesey St., Newark, N. J.

Parker Seal Co. has opened its new 20,000-sq ft research and development laboratory in Culver City, Calif.

Minneapolis - Honeywell Regulator Co.'s Semiconductor Div. will construct a million-dollar research and development center in Riviera Beach, Fla.

Telecomputing Corp. has purchased **Monrovia Aviation Corp.**, a wholly-owned subsidiary of Carrier Corp.

Westinghouse Electric Corp. will build a multi-million-dollar power transformer plant in Muncie, Ind.

Esso Research & Engineering Co. has moved into its new center in Florham Park, N. J.

Borden Chemical Co. will construct a combined resins and formaldehyde plant in the San Francisco Bay area.

International Radiant Corp. has moved to new quarters at 577 E. 156th St., New York 55, N. Y.

Societies

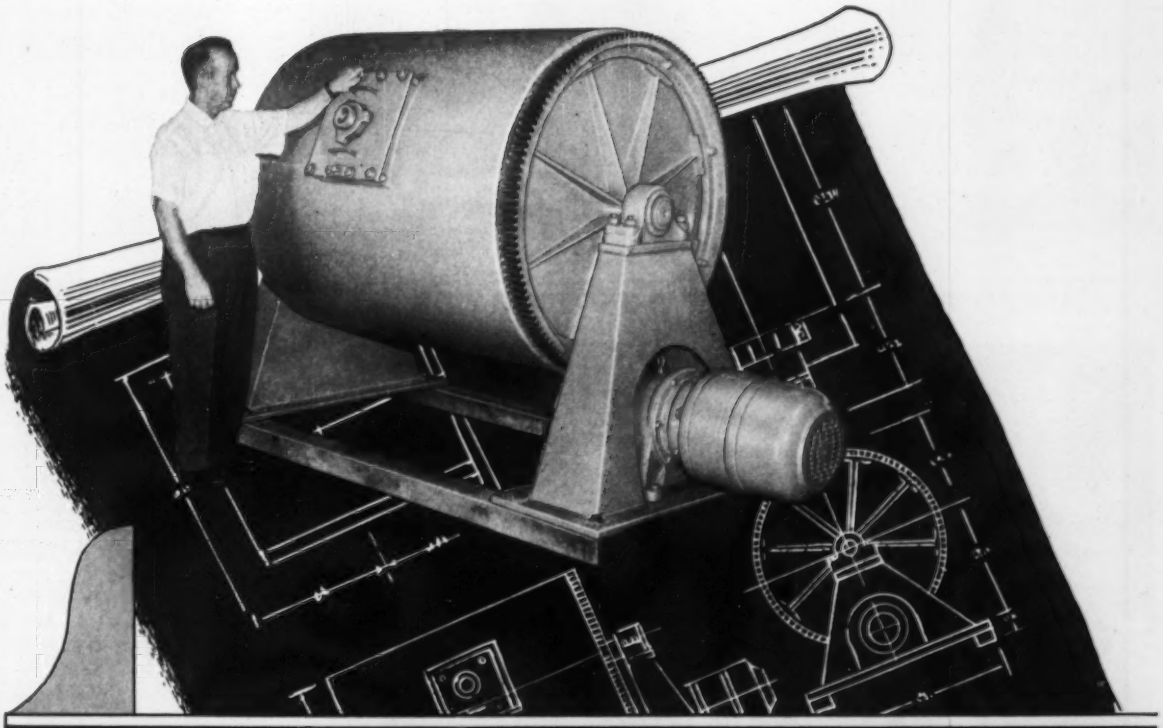
Metal Treating Institute has elected the following 1960 officers: president—C. Robert Weir, Commonwealth Industries, Inc.; vice president—John H. Ries, Lakeside Steel Improvement Co.; and treasurer—Lloyd G. Field, Greenman Steel Treating Co.

Epoxy Resin Formulators Div., Society of the Plastics Industry, Inc. has re-elected the following officers: chairman—L. R. Miller, Rezolin, Inc.; first vice chairman—John Delmonte, Furane Plastics, Inc.; and second vice chairman—Donald Roon, Houghton Laboratories, Inc.

Institute of Printed Circuits has announced the following new member companies: Fabri-Tek Circuits, Inc.; Becco Chemical Div., Food Machinery & Chemical Corp.; Burndy Corp.; Continental-Diamond Fibre Corp.; and Revere Copper & Brass, Inc.

Investment Casting Institute has elected the following officers: president—John H. Morison, Hitchiner Mfg. Co.; vice president, Management Div.—R. E. Gray, Gray-Syracuse, Inc.; vice president, Technical Div.—R. F. Waindle, WaiMet Alloys Co.; and treasurer—L. R. Schwedes, Lawrence Laboratory.

(News of Meetings on p 170)



PROPER PROTECTIVE COATING IS PART OF THE DESIGN

The modern product designer recognizes that his responsibility doesn't end until the product's *finish* has been specified. This is especially important when new machinery or equipment is destined for operation in areas where exposure to acids, corrosive fumes or high humidity may be a factor.

That's why more machinery and process equipment manufacturers are using Tygon* Protective Coatings. They find that Tygon, in one or more of its easily applied formulations, gives their products extra value, greater salability—provides the longer-lasting protection new equipment deserves.

HERE'S HOW TYGON CAN HELP YOU

No one coating solves all corrosion problems. But in the Tygon *family* of coatings there's all the help you need to provide the special protection your product may require to assure long-term, "customer-satisfying" performance.

Informed of the corrosive conditions your machinery or equipment may be expected to encounter in the field, we will be happy to analyze your coating requirements without obligation, and recommend the best and most economical coating for your specific application. This may be one of the well-known Tygon vinyl-based formulations, or perhaps a Tygon epoxy type coating will be best for the job.

Whatever your requirements, we can help you plan and execute a coatings program that sends your product to market properly protected for the job it is designed to do.

PLASTICS & SYNTHETICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

Find out how Tygon meets your corrosion problems. Write for Bulletin 760 today.

122-G

*Tygon is a registered Trade Mark of the U. S. Stoneware Co.

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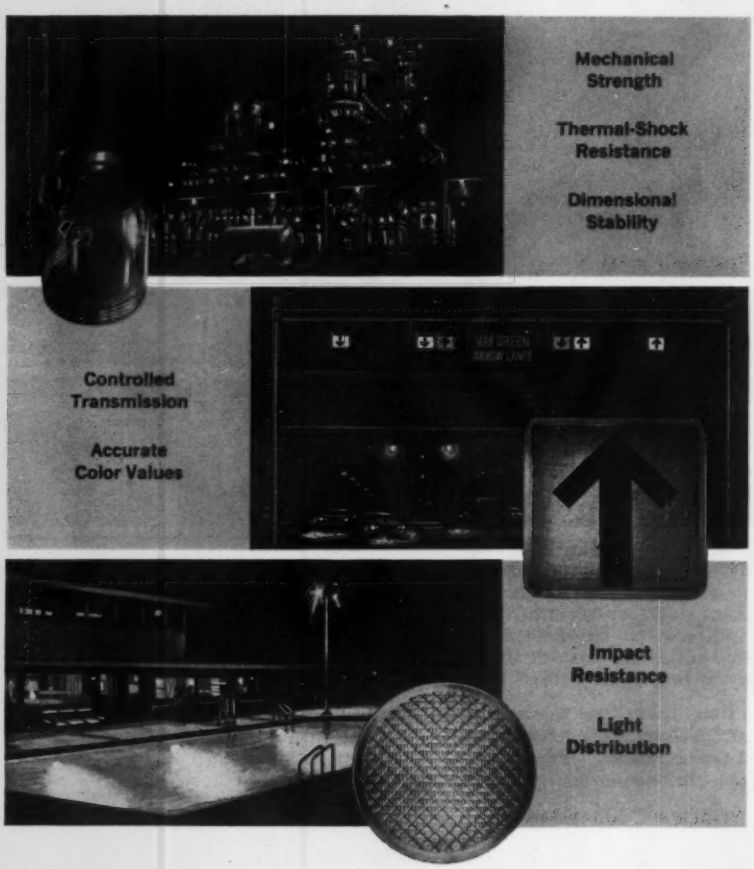
try GLASS

. . . there are so many advantages



Kopp Engineers help you get the right combination to meet your specific application requirements

Glass has so many useful and desirable properties and the extent to which these can be varied and controlled opens up almost unlimited design possibilities. That's where Kopp's engineering service comes in. Whether you require explosion-proof indicator lenses, heat-resisting lenses for swimming pools, floodlight cover glass, or traffic control lenses—Kopp has the engineering experience and manufacturing know-how to help you meet these requirements—*exactly*. Write us about your needs. Ask for Bulletin 553-A.

Specialists in engineered, custom-made glass

Kopp Glass, INC.

Swissvale, Pennsylvania

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News OF INDUSTRY

Meetings

SYMPOSIUM ON PROCESSING OF MATERIALS FOR RE-ENTRY STRUCTURES, Society of Aircraft Materials and Process Engineers, Mid-West Chapter. Dayton, Ohio. Mar 9-10.

TEMPERATURE MEASUREMENT SYMPOSIUM, Instrument Society of America. Columbus, Ohio. Mar 9-11.

INSTITUTE OF RADIO ENGINEERS, INC., national convention. New York City. Mar 21-24.

6TH NUCLEAR CONGRESS, Engineers Joint Council in cooperation with Instrument Society of America. New York City. Apr 3-8.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 17th annual SPI Western Section conference. Palm Springs, Calif. Apr 7-8.

SOCIETY OF THE PLASTICS INDUSTRY, INC., Cellular Plastics Div., automotive conference. Detroit. Apr 20-21.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 3rd annual Fluorocarbons Div. meeting. New Orleans. Apr 20-22.

SOUTHWEST METALS & MINERALS CONFERENCE, American Institute of Mining, Metallurgical and Petroleum Engineers. Los Angeles. Apr 21-22.

1960 POWDER METALLURGY SHOW AND MEETING. Metal Powder Industries Federation. Chicago. Apr 25-27.

AMERICAN WELDING SOCIETY, INC., 41st annual convention and welding exposition. Los Angeles. Apr 25-29.

SYMPOSIUM ON MATERIALS PROBLEMS IN SPACE FLIGHT SYSTEMS, Cincinnati, Dayton, Columbus Chapters, American Society for Metals. Cincinnati. Apr 27-28.

ELECTROCHEMICAL SOCIETY, spring meeting. Chicago. May 1-5.

2ND SOUTHWESTERN METAL EXPOSITION AND CONGRESS, American Society for Metals. Dallas. May 9-13.

DESIGN ENGINEERING CONFERENCE, Machine Design Div., American Society of Mechanical Engineers. New York City. May 23-26.

DESIGN ENGINEERING SHOW, New York City. May 23-26.

REFRACTORY MATERIALS AND ALLOYS SYMPOSIUM, Metallurgical Society, American Institute of Mining, Metallurgical and Petroleum Engineers. Detroit. May 25-26.

AMERICAN NUCLEAR SOCIETY, 6th annual meeting. Chicago. June 12-16.

R B & W FASTENER BRIEFS

MAKING THE MOST OF MODERN MECHANICAL FASTENING

Technical-ities

By John S. Davey

The choice between a cap screw and socket head screw

If you have the choice, make it a socket screw when you have a space problem, but choose the cap screw for more holding power per dollar.

No question that you should apply socket screws in counterbored holes; and that you can clear tight spaces. What you can't do is utilize the full strength of the alloy needed for the socket head. And remember, strength of a connection depends on how you preload the fasteners, and not on the strength of the fastener material alone.

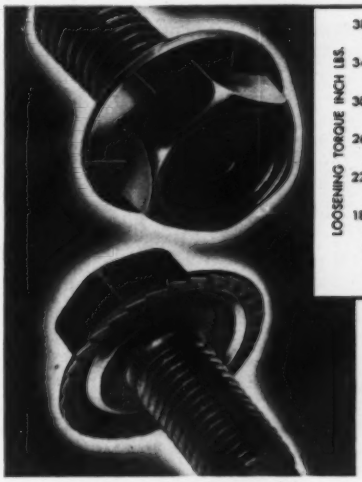
THE HANDICAPS OF ONE

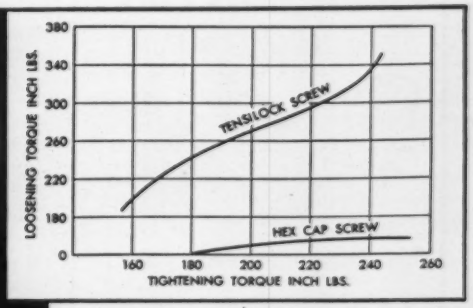
Internal wrenching rarely develops as much torque as needed for proper preloading. And if high torque is developed, the smaller bearing area of the socket head tends to crush the surface on which it bears rather than increase tension or preload.

THE ADVANTAGES OF THE OTHER

If you design to take advantage of heat treated cap screws of SAE grade 5 quality, you'll get a stronger connection at lower cost. These standard fasteners have ample bearing and wrenching surfaces, can be torqued right up to yield strength. They also cost less than the alloy fasteners.

New TENSILOCK* Screws seat tighter, lock tighter





Graph shows example of on-torque and off-torque relationship. It takes more torque to loosen than to tighten.

RB&W's new TENSILOCK screws, the toothed fasteners with high tensile locking, are identified by six radial dashes on flange.

Head has integral washer face with teeth that lock fastener to surface. Circular groove allows flange to flex and seat to bear solidly on surface.

RB&W's TENSILOCK fasteners feature ratchet-like teeth formed at an angle which cuts driving effort yet which enables the teeth to bite in firmly and give an improved grip against back-off.

In addition, a circular groove in the integral "washer" permits the flange to flex upon tightening, and helps maintain tension in the fastener and pressure on the teeth.

IMPROVED TENSION TO TORQUE RATIO

With reduced friction under the head, the new tooth design has enabled more of the wrenching torque to be used to develop tension and less to overcome friction. Since the flange flexes, it allows the screw to bear solidly on its seat. All of the high strength capabilities of these heat-treated one-piece fasteners can now be attained for a stronger assembly.

MORE LOCKING POWER

Tensilock screws need up to 40% more off-torque than on-torque. Combining this feature with the higher residual tension, and the diaphragm action of the integral washer face, these fasteners give superior locking and holding power for permanently tight, strong joints . . . even under severe vibration and cyclic temperature changes.

Now available in limited range of screw types (not in flat head), and in various nut sizes. For details, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

* Trade Mark Pat. applied for.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

For more information, turn to Reader Service card, circle No. 331

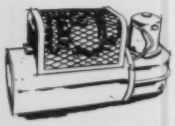
When you're choosing a protective coating...

HOW HOT IS YOUR HOT?

A Nose Cone Gets Hot

When conventional organic finishes were used in Chrysler Redstone Missile tests, they ignited and disintegrated under simulated re-entry conditions. Sicon survived because it possessed the inherent heat resistance to meet performance requirements. This has been confirmed in large scale tests and actual missile firings.

A Truck Heater Gets Hot



A porcelain type coating used on a truck heater failed because it could not stand the thermal shock of rapid heating and cooling. The same heating (550°-600°F.) and cooling left Sicon's film integrity unaffected.

A Tractor Engine Gets Hot

A farm equipment manufacturer used a bright organic red color on their standard equipment. The coating on the engine parts, which were subjected to high temperature, quickly decomposed. Midland engineers developed a matching bright Sicon Red which retained its color and gloss and protected the hot spots on the engine.

How HOT is your HOT?

Sicon possesses the flexibility of ordinary organic finishes and the heat resistance of ceramic coatings—up to 1000°F. in black or Aluminum; up to 550°-600°F. in decorative colors. Upon inquiry a sample Sicon formulation for testing your "hot" requirements will be prepared at no obligation. Send details of your "hot spot" problem today to Dept. C-1.

Sicon®

HEAT RESISTANT FINISH

A Silicone Product of

MIDLAND

INDUSTRIAL FINISHES COMPANY

WAUKEGAN · ILLINOIS

ENAMELS · SYNTHETICS · LACQUERS · VARNISHES

For more information, card, circle No. 448

ENGINEERING & DESIGN

Honeycomb—continued from p 122

increased corrosion resistance is desired.

Steel is used in some applications for facing on honeycomb sandwiches. For example, stainless steel has been used in the construction of exterior panels for modern buildings, and porcelain enamel-coated steel has also proved successful in the same application. Variations of steel facing materials are also used in flooring applications.

Nonmetallics—Glass cloth, resin-impregnated, can be used as a facing material for structural applications. A wide range of directional facing strengths can be obtained by using different weaves and by properly orienting the fibers.

Fiberglass mats are another commercially available facing material. These mats are similar to glass cloth in final appearance and function; however, glass cloth provides a smoother surface with a more consistent facing thickness.

Paper facing materials, resin-impregnated, have been used for flat, nonstructural panels such as interior walls and partitions. However, in applications where highly concentrated loads might be applied to the panel, such as a bump with a sharp cornered object, impregnated paper facings are highly susceptible to tearing or puncturing. In applications where this type of load is not likely to occur and moisture resistance and flammability are not considerations, paper provides the lowest weight facing of the least expensive type.

Plywood as a facing material has found wide use in both structural and nonstructural honeycomb sandwich applications. One very common nonstructural use for plywood facing is in the fabrication of internal and external doors of buildings. Here the plywood is bonded to a honeycomb core of paper, providing a thin, lightweight structure that has excellent heat and sound insulating properties.

New data on the durability of

Nickel and Chromium Electroplates

■ Details on new electroplating processes for zinc die castings and results of recent corrosion studies were revealed at a special symposium of the American Zinc Institute held in Detroit, Nov '59. New data presented at the session should prove beneficial to all users of electroplated zinc die castings, especially automotive and appliance engineers.

Thicker chromium improves corrosion resistance

In a report on "The Role of Chromium in Protecting Zinc Base Die Castings," H. Mahlstedt and E. J. Seyb, of Metal & Thermit Co., reported increasing evidence that chromium not only improves tarnish resistance but can substantially improve the corrosion resistance of zinc and other base metals.

Chromium has always been known for its corrosion resistance but when used in flash thicknesses, as it has been for many years, it was thought that it provided only tarnish resistance and did not protect the base metal. However, tests now show that increasing the thickness from the usual 0.01 mil to as high as 0.05 and 0.07 mil can improve durability five to ten times.

The authors also reported that the protection provided by Metal & Thermit's Bright Crack-Free Chromium when used alone is believed to result from the continuous, impervious chromium layer which does not permit corrosion to penetrate to undercoatings. Furthermore, the system of using a layer of Bright

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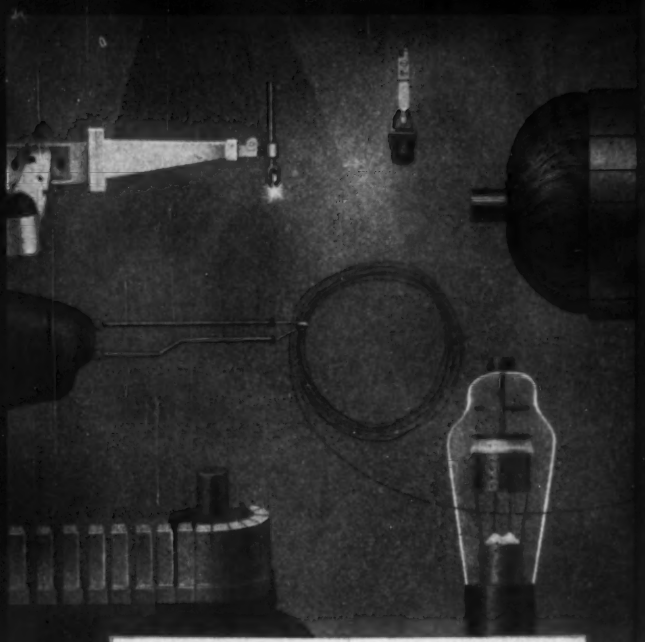

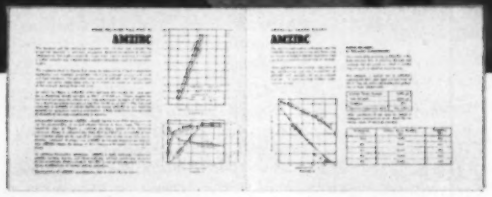

Eight-page booklet illustrated with charts and graphs. Gives metallurgical data on patented copper-zirconium alloy having tensile up to 52,000 psi at 400C plus room-temperature conductivity of 95% IACS; extreme notch toughness; exceptional hot and cold workability.

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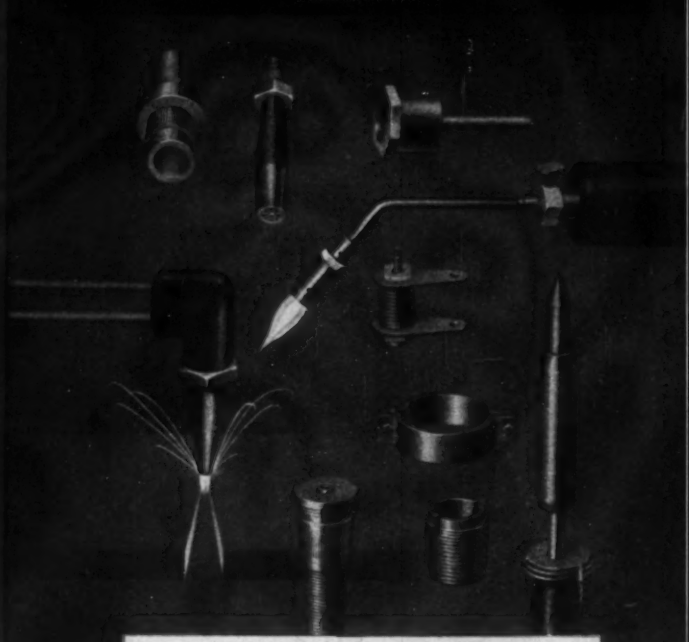

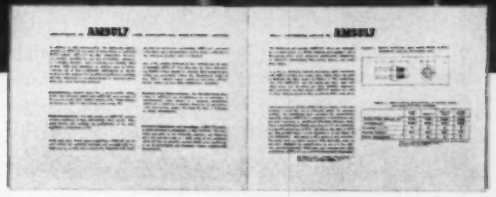

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STRAITS TIN REPORT

News of developments in the production and uses of tin

MALAYAN TIN BUREAU

Automatically soldered printed circuits are substituted for a maze of wires and relays in the instrument panel of the 1960 Mercury. This is another example of the use of tin-lead solder to help reduce electrical failure and simplify service.

Tin cuts bacteria 80% on hospital floors—according to Columbia University research on the organotin compound tributyltin oxide (TBTO). Certain other compounds from nontoxic tin salts can become powerful biocidals, rivaling DDT as insecticides. Tanners use them as disinfectants; paper mills as slimicides and antimold-growth agents in water systems.

Tin replaces chromium as a coating for trumpet valves and trombone slides. The antifriction alloy of tin and nickel has a high degree of lubricity, reduces excessive wear.

Architects are rediscovering the tin roof . . . century-old terne roofing is making a comeback as an economical, corrosion-resistant and fireproof covering. Terne, tinplated steel sheets, offers permanent protection. Lighter than other metal roofing, it ends need for special load-bearing substructures. Tensile strength is high; no cracking or creeping with climate changes.

Write today for more data on these items or for a free subscription to TIN NEWS—a monthly bulletin on tin supply, prices and new uses.

The Malayan Tin Bureau
Dept. 24C, 2000 K Street, N.W., Washington 6, D.C.

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ENGINEERING & DESIGN

Crack-Free Chromium under a second chromium layer applied under special conditions produces outstanding corrosion protection. The average proportion of the two layers is usually about 50:50. This new system is now being called duplex, dual, or double chromium.

Duplex chromium has a fine crack pattern on top and is believed to provide corrosion protection by breaking up the corrosion cell into small units so that the anode current is extremely small for any particular corrosion cell. Thus, it takes a very long time for base metal corrosion products to form. Tests with duplex chromium show excellent corrosion protection with 0.05-mil thickness and even more outstanding protection at thicknesses of 0.2 mil. Corrosion protection is much better than that provided by 0.01 mil of ordinary chromium used over duplex nickel or over conventional single bright nickel deposits.

Report on nickel

In his paper "The Contribution of Nickel and Chromium to the Durability of Decorative Plating," C. H. Sample, of International Nickel Co., Inc., concluded that the general quality of decorative nickel-chromium plating has appreciably improved during the past year or so and that even more marked improvements can be expected. In a summary of recent technical developments he also reported that:

1. Fully bright nickel is generally inferior to buffed dull nickel of the same thickness, when plated with conventional chromium in normal thickness.

2. Duplex nickel coatings, when plated with conventional chromium of conventional thickness, provide corrosion protection substantially equivalent to that of chromium-plated buffed dull nickel of the same thickness.

3. A marked improvement in corrosion protection is obtained by applying heavier-than-normal chromium coatings to bright nickels that are adversely affected by conventional chromium plating.

4. Combination coatings of copper, bright nickel and conventional chromium provide better protection than

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replaces costly metal fabrications

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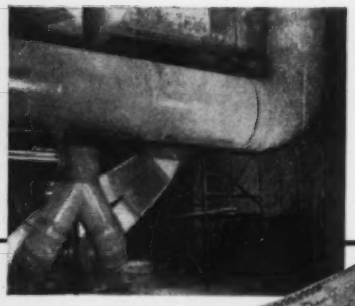

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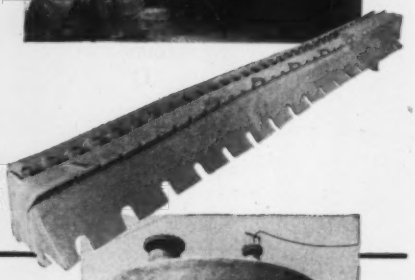

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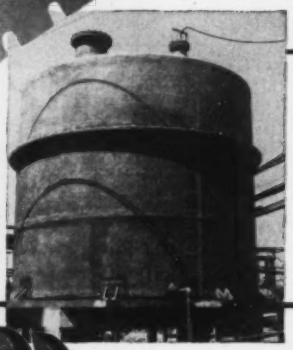
Acid storage tanks, tank trailers, exhaust systems, pressure pipes and other Duracor products are rendering outstanding service.



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Tensile Strength p.s.i.: 11,000-15,000

Flexural Strength p.s.i.: 20,000-30,000

Tensile Modulus of Elasticity p.s.i.: 1.2—1.4 x 10^6

Flexural Modulus of Elasticity p.s.i.: 0.78—1.6 x 10^6

Impact Izod, Notched ft.-lbs./in.: 30—40

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Coefficient of Linear Expansion: 9.5 x 10^{-6} in./in./°F.

Standard Color: Light Green/Gray

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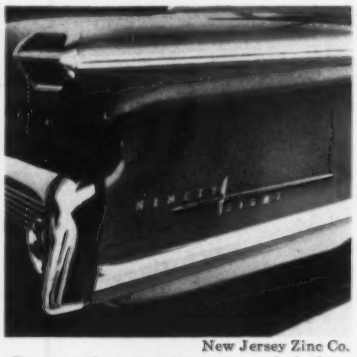
comparable coatings without copper, but only for a short time. However, even at best such coatings fall far short of the high durability standards established years ago with buffed dull nickel plus conventional chromium, and with the duplex nickel systems now available.

How three types of chromium compare over duplex nickel

Previous reports have stated that substantial improvements in the protection of zinc die castings—on the order of 25 to 33%—can be obtained by using chromium plate over duplex nickel (Doehler Double Plate). Startling results have been obtained by using this system on 1958 auto parts, and the appearance of parts after one winter has been far superior to that of similar parts plated with equal thicknesses of copper, nickel and chromium. Results were so successful that Doehler-Jarvis Div., National Lead Co., started using the system on all 1959 automotive exterior parts.

The effects of using different types of chromium systems over duplex nickel are given in an "Evaluation of Modern Methods of Improving the Corrosion Resistance of Zinc Base Die Castings," by M. R. Caldwell and L. B. Sperry of Doehler-Jarvis. Their experience shows that the three chromium plates (baked or unbaked) that give the best all-around performance over duplex nickel in accelerated corrosion tests are: 0.01-mil sulfate type; 0.03-mil duplex sulfate type; and 0.05-mil



New Jersey Zinc Co.

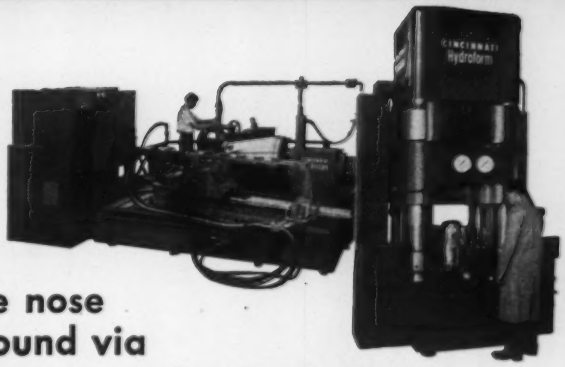
***Decorative quality** of nickel-chromium plating has improved appreciably in recent years—as exemplified by the plated zinc die castings used for the name emblem and tail light frame of this 1960 Oldsmobile.*

For more information, circle No. 422 ➤

Fig. 2

Fig. 2, above. Sonic measurement of finished Hydrospun Nike Hercules nose cones. Thickness of the tapered wall is held to ± .006". Photos and data courtesy of Lycoming Div., Avco Corp., Stratford, Conn.

Cincinnati® Hydroform® machines are built in 8", 12", 19", 23", 26" and 32" sizes; Hydrospin® machines are built in a variety of styles and sizes to meet your production requirements.



Another missile nose gets off the ground via

CINCINNATI Hydroform/Hydrospin!

NIKE HERCULES NOSE CONES are in quantity production at Lycoming (Stratford) Div., Avco Corporation, subcontractor to Douglas Aircraft Co., Inc., Charlotte Div., for these missile components. The success of this work is due to the unique capabilities of Cincinnati Hydroform and Hydrospin machines to form the nose cone to the desired contours and to the degree of precision required.

In the foreground of Fig. 1, below, are shown the five work stages to produce the finished part. "A" is the 17" dia. blank of ½" thick, annealed 6061 aluminum, which is preformed by a Cincinnati Hydroform to the shape shown at "B". Parts "C", "D" and "E" represent the nose cone shape progression through three passes on a Cincinnati Hydrospin. Wall section of the final shape is tapered from .078" at the nose to .125" at the aft end, with wall thickness controlled by the Hydrospin to ± .006". The metal of the finished part is solution heat treated to a T6 condition.

This winning Hydroform-Hydrospin combination is aiding missile and many other component parts manufacturers to produce formerly difficult or impossible sheet metal shapes to specified tolerances . . . while producing major savings in *time, tooling, labor* and *material costs* as well. Look into the many advantages of Hydroforming and Hydrospinning. Call in a Meta-Dynamics Division field engineer for full details.

Hydroform/Hydrospin
META-DYNAMICS DIVISION
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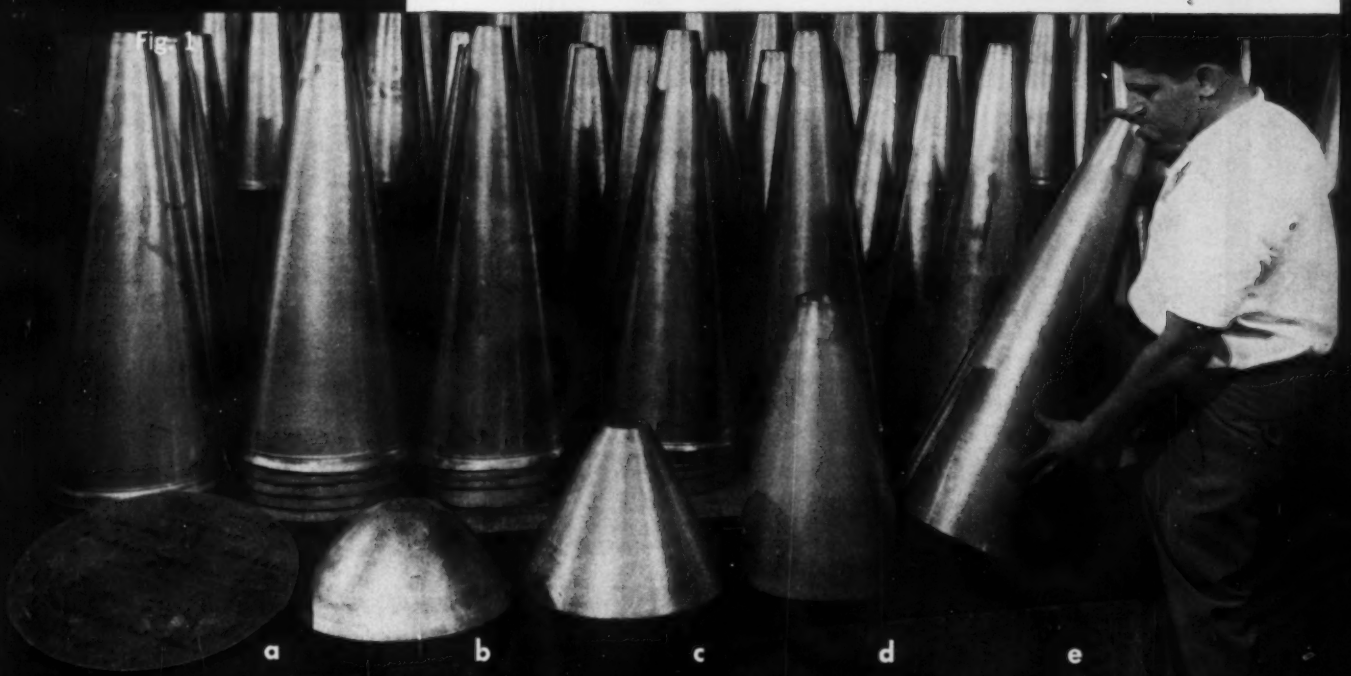
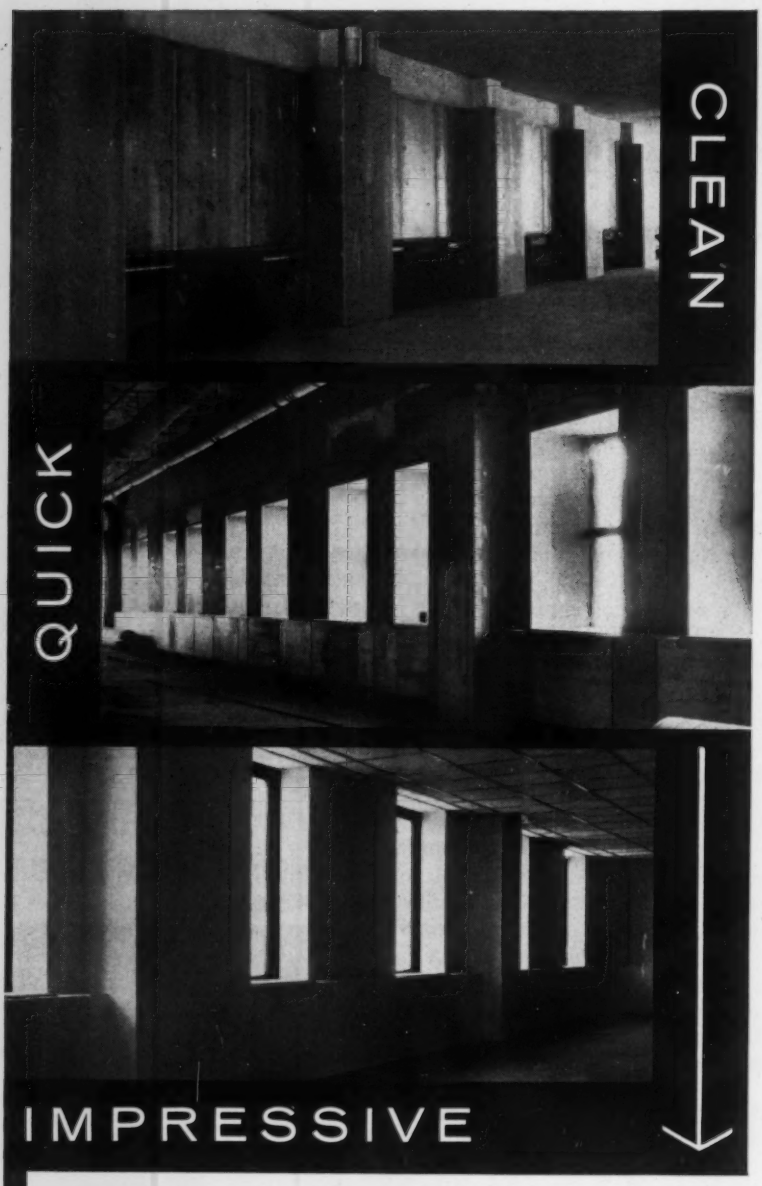
Fig. 1





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Progressive installation photos from Vulcan Building, Cleveland, Ohio. McDowell Company acted as its own general contractor and Hubbell & Benes and Hoff, Inc. were associate engineers and architects.

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fluoride type A.

None of these plates showed any significant base metal corrosion. The 0.01-mil sulfate-type chromium showed only surface pitting after 80 hr in the CASS test and 100 hr in the Corrodkote test. In fact there was no pitting at all at the end of two 20-hr cycles in the Corrodkote test.

Similarly, after 80 hr of CASS and 100 hr of Corrodkote testing, the 0.03-mil duplex sulfate-type chromium showed only surface pitting on unbaked panels and only cracking on baked panels. In the same test the 0.05-mil fluoride type chromium showed only cracking, which was increased by baking.

The authors concluded that it is obviously more economical to apply 0.01 mil of a single chromium plate than 0.03 mil of a duplex plate or 0.05 mil of another single plate. Also, the 0.01-mil sulfate-type chromium plate appeared to perform just as well over duplex nickel as the other chromium plates evaluated. They also pointed out that the effect of baking on corrosion resistance must be considered on parts that are painted and baked after plating.

New crack 'printing' method—Many of the test panels were examined prior to testing by the new electrographic printing method that has been successfully used at Battelle Memorial Institute. This method reveals any cracks or pores through the chromium down to the nickel. Photographic paper dampened with a solution of dimethylglyoxime is placed on each panel. A pressure of 10 psi is applied and the panel is then made anodic. Suitable current is applied, and wherever nickel is exposed by cracks or pores in the chromium plate, nickel dimethylglyoxime is formed, producing a red pattern of the cracks of the paper.

Dangers of using accelerated test data

According to R. B. Saltonstall of the Udylite Corp., in discussing "Correlation of Outdoor Exposures, Service and Accelerated Tests on Chromium Plated Bright Work," the performance of chromium and nickel-plated auto trim is directly dependent on plating thickness. Failure to specify adequate bright nickel thickness, and/or failure to enforce

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That's why they use the Ransburg Electrostatic Hand Gun to apply a uniform clear coating on their brass-plated furniture. The protective coating is baked on. Although the bulk of their present production is in the popular brass line, they still paint the metal furniture in a variety of colors with the Hand Gun.

Painting is CLEANER ... QUICKER ... CHEAPER *with the Ransburg Electrostatic Hand Gun.*

These chairs and table are typical of the Koch line of metal furniture.

*10 GALLONS OF PAINT NOW DOES THE JOB WHICH FORMERLY TOOK 30 GALLONS

On one item—a TV table—they formerly used 30 gallons of enamel to coat 1000 units by combination dip and air spray method. Now—with the Ransburg Electrostatic Hand Gun, they paint 1000 tables with only 10 gallons. And, they get a better, more uniform coating, too.

NO REASON WHY YOU CAN'T DO IT, TOO!

See how the Electrostatic Hand Gun can save time . . . paint . . . and cut costs in YOUR finishing department. Or, if your production justifies, it'll pay you to investigate Ransburg's automatic electrostatic spray painting equipment. Write for our No. 2 Process brochures which show numerous examples of modern production painting in both large and small plants.

RANSBURG

RANSBURG
Electro-Coating Corp.
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specifications, have resulted in untimely failures.

The author also claims that there is a danger of being lulled into a false sense of security if the designer predicts the susceptibility of plated parts entirely on the basis of accelerated tests. A case in point are the false conclusions made from Corrodkote tests which showed striking improvements when very thin chromium was deposited over thin bright nickel. Lowering of nickel thickness on the basis of such tests without service correlation may be premature.

How Dangerous Are Plastics in Fires?

Fears are frequently expressed that plastics involved in fires will yield toxic combustion products such as hydrogen cyanide gas. It has been claimed, but later disproved, that hydrogen cyanide would be a major hazard if melamine resins were involved in fires.

A hazard certainly exists when plastics are involved in fires, but apart from extra smoke the principal hazard is carbon monoxide and oxygen deficiency, both of which are always present in fires.

This is the conclusion drawn by E. H. Coleman who recently reviewed published British and American literature on the subject. Coleman's review, which appeared in the Oct '59 issue of the British magazine *Plastics*, shows the following:

1. Chlorinated plastics may evolve hydrogen chloride in proportion to the chlorine content of the plastic. However, more carbon monoxide will be evolved since the major portion of the material is cellulosic.

2. Cotton, paper and wood fillers increase the concentration of carbon monoxide in burning phenolic and melamine resins.

3. Nitrogenous materials such as wool and certain plastics resins may evolve some cyanide and ammonia.

4. Fluorine compounds such as TFE resin may evolve hydrofluoric acid and gaseous fluorocarbon compounds. The fluorocarbon compounds would probably be evolved at lower temperatures early in the fire.

Organic Acids Causing Corrosion?

...Test **HAYNES** Alloys

HASTELLOY alloy C and nine other corrosion-resistant alloys were tested in hot acetic acid vapors containing traces of oxidizing contaminants. HASTELLOY alloy C had a penetration rate of only 0.0007 inches per year—lowest among all nine competitive alloys. Others varied from 0.005 to 0.5 inches per year and were severely pitted. This test showed one manufacturer of organic chemicals how he could keep his maintenance costs to a minimum before a process was even on stream.

How much money can you save in your plant? Why not find out for sure by testing HAYNES alloys.

We'll gladly send you samples. There are 6 HAYNES corrosion-resistant alloys. To help us select the one most likely to solve your problem, we suggest that you send us a letter outlining the corrosive conditions in your plant. To learn more about HASTELLOY alloys, ask for a copy of our 104-page book. It describes the alloys in detail.

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TECHNICAL LITERATURE

(cont'd from p 47)

Books

Structure and Properties of Thin Films. *Edited by C. A. Neugebauer, J. B. Newkirk and D. A. Vermilyea. John Wiley & Sons, Inc., New York. 1959. Cloth, 8½ by 11 in., 575 pp. Price $15*

During the past several years there has been an increasing amount of effort expended on fundamental studies of matter in the form of thin metallic films. Examples of such research are found in several papers in this book, and include studies of phase transformations, chemical reactivity, superconductivity, electrical resistance, magnetic properties, magnetoresistance, chemical behavior, and mechanical properties.

In addition to papers dealing primarily with properties of thin films, the book contains many papers dealing with the problems of film growth and characterization. These papers include direct observation of defects, structure studies including low energy electron diffraction, measurements of specific surface area, and observations of the state of stress in the films.

Other papers in the book deal with surface chemistry and theoretical research.

Phenolic Resins. *David F. Gould, Reinhold Publishing Corp., New York. 1959. Cloth, 7½ by 5 in., 220 pp. Price $5.75*

Discusses the status, manufacture and use of phenolic resins. Gives information on phenolic molding compounds, adhesives, laminates, coatings and foams. Information also on the use of phenolic resins in wood products and rubber compounds.

The Performance of Lubricating Oils: 2nd Edition. *H. H. Zuidema. ACS Monograph No. 143. Reinhold Publishing Corp., New York. 1959. Cloth, 6 by 9 in., 215 pp. Price $7*

Information on lubrication processes, rheology, oxidation, bearing corrosion, sludge and lacquer deposition, emulsification and foaming, and manufacturing methods.

Epoxy Resins: Market Survey and Users' Reference. *Materials Research, P. O. Box 363, Cambridge, Mass. 1959. Paper, 8½ by 11 in., 220 pp. Price $18.50*

The various chapters and appendices give information on the size of the epoxy resin industry, resin producers and formulators. The book also discusses the use of epoxy resins in the aircraft, automobile, container, appliance, boat, petroleum, railroad and textile industries.

Soldering Manual. *American Welding Society, New York. 1959. Cloth, 6 by 9 in., 180 pp. Price $5*

The 21 chapters deal with the following subjects: principles of soldering; solders; fluxes; joint design; precleaning and surface preparation; equipment, processes and procedures; flux residue treatment; inspection and testing; copper and copper alloys; steel; coated steels; stainless steels; nickel and

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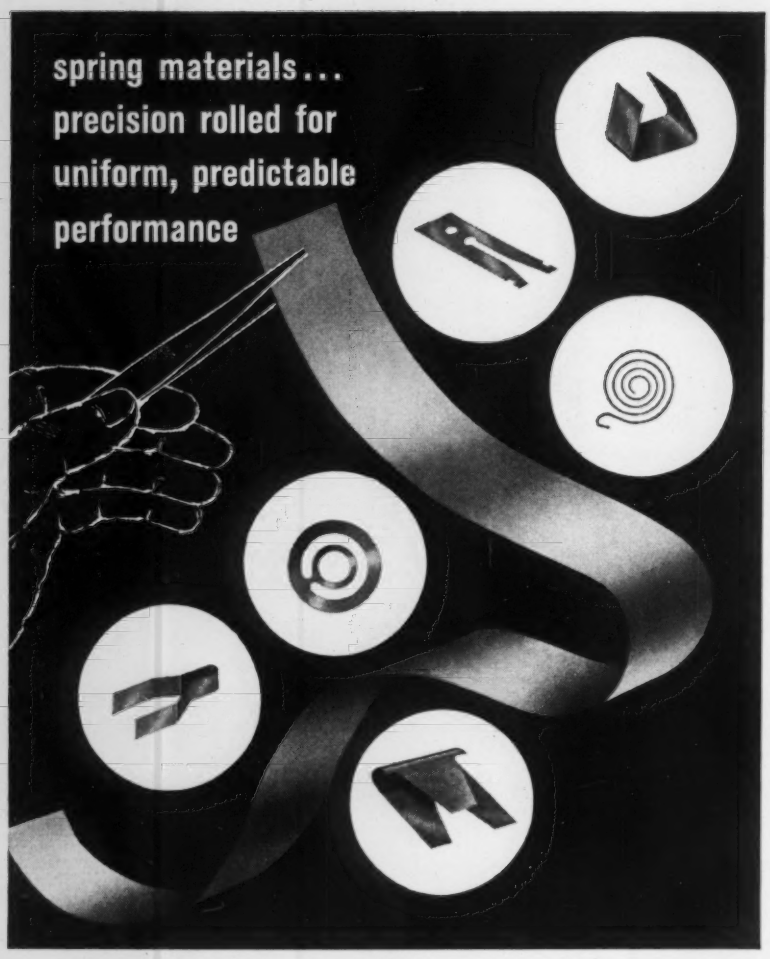

Here—from Precision Metals Division of the Hamilton Watch Company—are important new spring materials. Now available in production quantities are flat wire and metal strip of Beryllium Copper, Elinvar, Havar, Stavar, Inconel Extra and Age-Hardening Stainless Steel.

The newly expanded and completely integrated Precision Metals Division is producing these spring materials with these unusual advantages:

thicknesses from .010" to .0001"
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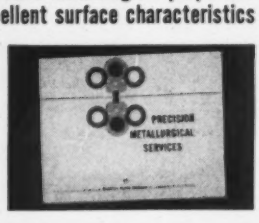
dimensional uniformity

controlled metallurgical properties
excellent surface characteristics

In addition, Precision Metals Division will also furnish special alloys to your own specifications in the particular form you require. Write today for a copy of facilities booklet DE-3 or mail your prints for proposal.



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Lancaster, Pennsylvania

Representatives
COREY STEEL COMPANY • Chicago, Illinois
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TECHNICAL LITERATURE

high nickel alloys; lead and lead alloys; aluminum and aluminum alloys; tin; cast irons; precious metal coatings; printed circuits; and safety.

Reactive Metals, Volume 2. *Edited by W. R. Clough. Interscience Publishers, Inc., New York. 1959. Cloth, 6 by 9 in., 624 pp. Price $15*

Subjects of the 37 papers given in this book include: properties and uses of titanium alloys; powder metallurgy techniques for zirconium, molybdenum and titanium; melting and refining reactive metals; physical metallurgy, including temperature effects, phase relationships and interstitial effects; nuclear applications for reactive metals; and reactive metal processing and fabrication.

Reports

Design of aluminum products DESIGN FORECAST, VOLUME 1, NO. 1. *Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19. 64 pp. Subscription price $5 for two issues, $2.95 per copy.*

First issue of a new semi-annual, hard-bound magazine gives information on expanded aluminum sheet; and use of aluminum in appliances, automobiles, toys, furniture and houses. Also gives information on techniques for joining aluminum, impact extrusions, and aluminum alloys.

Fire tests for wood FIRE-TEST METHODS USED IN RESEARCH AT THE FOREST PRODUCTS LABORATORY. *1959. 56 pp. Forest Products Laboratory, Madison 5, Wis. (No. 1443)*

Technical education INTERNATIONAL BIBLIOGRAPHY OF TECHNICAL AND VOCATIONAL EDUCATION. *Unesco. 1959. 74 pp. Available from Columbia University Press, 2960 Broadway, New York 27, N. Y. Price $1 (No. 31)*

Brazing titanium sandwiches BRAZING TITANIUM SANDWICH CONSTRUCTIONS. *J. F. Rudy, R. M. Neckeles and H. Schwartzbart, Illinois Institute of Technology. Jan '59. 98 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.25 (PB 151663)*

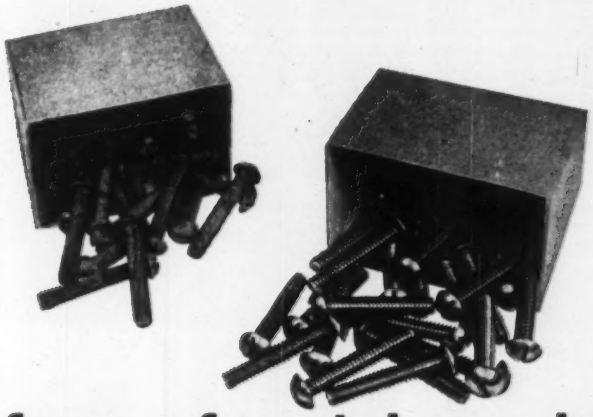
Describes face sheets, brazing alloys and techniques used for brazing titanium sheet honeycomb sandwiches.

Commercial standards INDEX OF COMMERCIAL STANDARDS. *1959. Commodity Standards Div., Dept. of Commerce, Washington 25, D. C. (Catalog No. 978)*

Lists commercial standards for wood products, plastics, thermal insulating materials, rubber, paper, textiles, precious metals, petroleum products, chemicals, electrical and mechanical equipment, instruments and tools, and hardware. The standards are adopted by industry to establish nationally recognized quality requirements, including methods of testing, rating and grading.

Metal-impregnated carbide IMPREGNATION OF SILICON CARBIDE ARTICLES WITH METALS. *Translated from the Russian "Ogneupory," 1957, No. 12. Available from Henry Brutcher, P. O. Box 157, Altadena, Calif. Price $6.60 (HB 4504)*

Discusses gas-phase impregnation of silicon carbide parts with metals.



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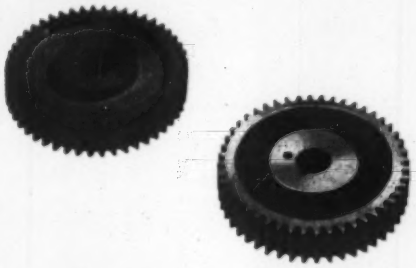

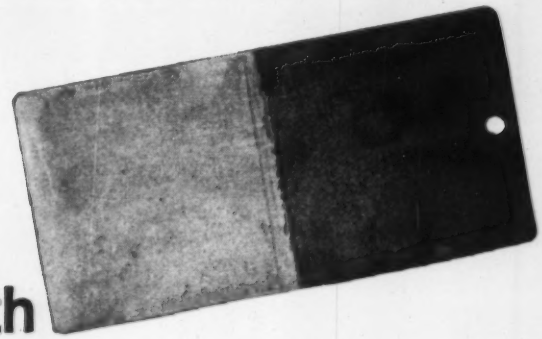

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☐ B. Booklet—"Sodium Nitrite for Rust and Corrosion Prevention"—SP-33A

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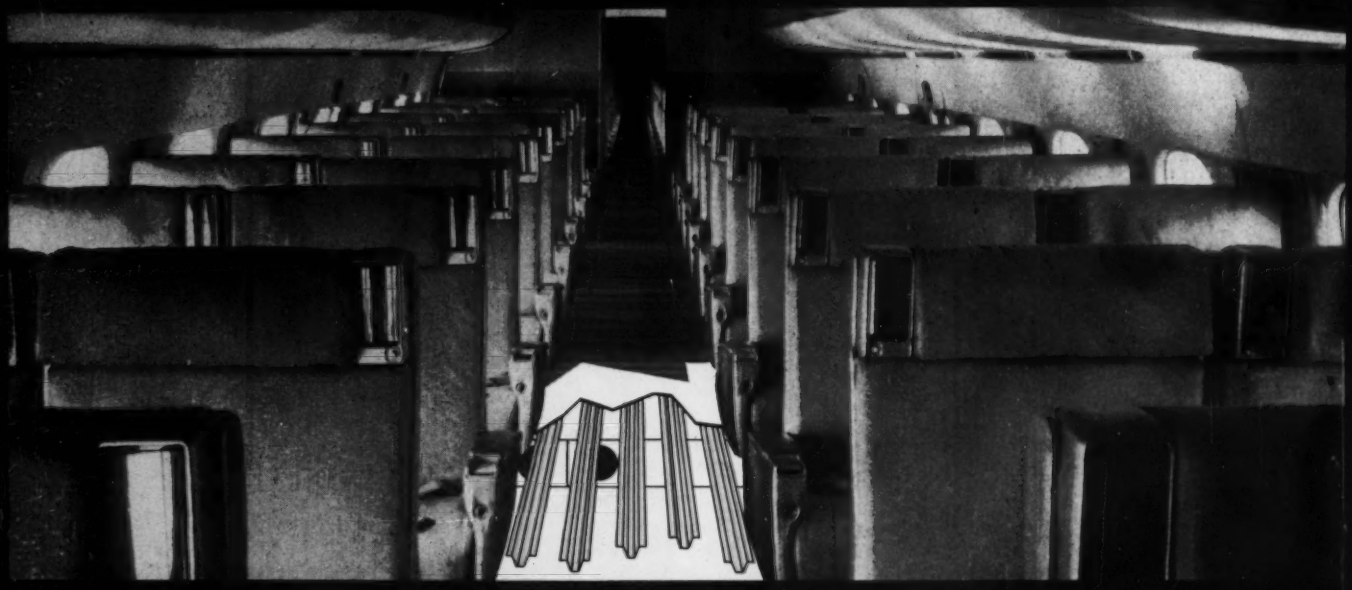
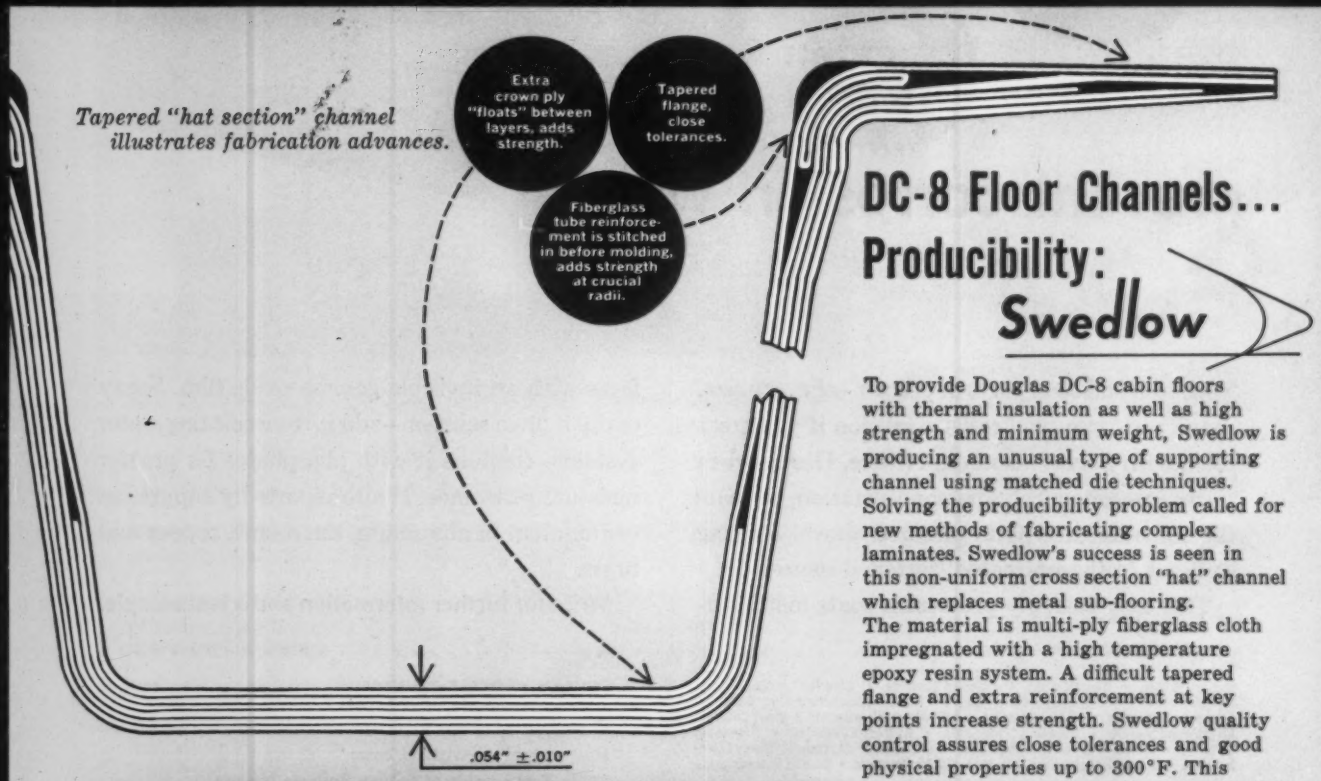
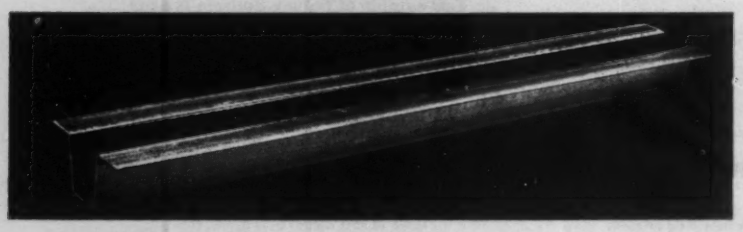


meeting the challenge of

THE STRENGTH/WEIGHT PROBLEM

Tapered "hat section" channel illustrates fabrication advances.


Extra crown ply "floats" between layers, adds strength.
Tapered flange, close tolerances.
Fiberglass tube reinforcement is stitched in before molding, adds strength at crucial radii.
.054" ±.010"



DC-8 Floor Channels... Producibility: Swedlow

To provide Douglas DC-8 cabin floors with thermal insulation as well as high strength and minimum weight, Swedlow is producing an unusual type of supporting channel using matched die techniques. Solving the producibility problem called for new methods of fabricating complex laminates. Swedlow's success is seen in this non-uniform cross section "hat" channel which replaces metal sub-flooring.

The material is multi-ply fiberglass cloth impregnated with a high temperature epoxy resin system. A difficult tapered flange and extra reinforcement at key points increase strength. Swedlow quality control assures close tolerances and good physical properties up to 300°F. This development of Swedlow skills and materials holds promise in many applications requiring high strength-to-weight ratios, temperature resistance and precise fabrication.

Write for technical bulletin.

Please refer to Dept. 18

SWEDLOW Inc.

LOS ANGELES 22, CALIFORNIA

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For more information, turn to Reader Service card, circle No. 440

Tungsten coatings *are applied on metal by passing hydrogen and tungsten hexafluoride over an object to be plated in the ceramic cylinder shown at left.*

(cont'd from p 16)

High Purity Tungsten Coatings Applied by Gas Plating

High purity tungsten can easily be deposited on complex metal and nonmetallic parts by using a new gas plating technique. The method was developed by W. E. Reid and A. Brenner of the National Bureau of Standards, Washington, D. C.

The NBS gas plating technique is similar to a method developed by the Bureau of Mines for forming tungsten into tubing and other shapes (see M/DE, Dec '59, p 162).

Properties, uses

The Bureau says its new gas plating technique can be used to coat rocket and missile nozzles, jet engine parts, and wires. It can also be used to fabricate simple and complex tungsten parts.

Laboratory tests show that tungsten deposited by gas plating is nonporous, and purer than commercial tungsten metal. Other tests show the deposit has a density of 0.70 lb per cu in., and a hardness of 475 VHN. Tungsten deposited by gas plating is said to adhere well to molybdenum, copper, graphite and some ceramics.

How process works

The method, still under development, consists of passing a mixture of gaseous tungsten hexafluoride over a part to be coated. The part is heated to temperatures ranging from 570 to 1650 F. At temperatures over 1100 F, tungsten is extracted from the gaseous mixture and deposited as pure metal on the hot part. Impurities pass out with excess gas. (For more detailed information on gas plating, see M/DE, Jan '60, p 98.)

Open-Cell PVC Foam Is Heat Sealable

A heat sealable, open-cell PVC foam is being supplied in production quantities by Highside Foam Products, Inc., 10 Colfax Ave., Clifton, N. J.

A low density foam, it is said to be the only vinyl foam currently being produced by a continuous chemically blown process. The continuous process is said to produce a foam of uniform quality.

The material, called Hi-Vi, is said to have good resistance to humidity, sunlight, water and air. Because it can be compressed and heat sealed, the foam is well suited for use in quilted products and shaped cushions. It is currently available in the form of sheets in lengths up to 48 in. and in thicknesses down to ⅛ in.

KEY NO. 608

For more information on new materials, note key number and circle it on Reader Service card.

Electrical Insulations Announced at Meeting

Three new developments in electrical insulating materials of particular interest to designers and engineers were announced at the 2nd National Conference on the Application of Electrical Insulation held recently in Washington, D. C.

A fourth development, the announcement by three companies of a low temperature curing silicone impregnating varnish, is covered elsewhere in this issue (p 194).

1. Cyanoethylated kraft paper

Cellulosic electrical insulation modified by a new "cyanoethylation" process is said to have excellent resistance to thermal degradation. In the new process cellulosic materials are treated in the raw pulp stage to replace hydroxyl groups with cyanoethyl groups.

Dielectric properties of the new material are said to hold up for long periods under temperatures that would quickly degrade untreated cellulosic insulation. Thus, transformers insulated with the new material can be run at higher temperatures without shortening their lifetime.

Information on the properties and uses of cyanoethylated kraft insulation was given in a paper written by J. C. Lesile, General Electric Co., N. L. Greenman, Rogers Corp., and H. W. Knudson, Hollingsworth & Vose Paper Co.

Laboratory and field tests indicate that: 1) tensile strength retention of a cyanoethylated kraft insulation is 74% after aging 140 days in oil at 300 F, compared to 35% for rag paper insulation and 14% for a standard kraft insulation; and 2) cyanoethylated kraft paper insulation aged in a sealed oil system with Formex wires increases wire life five to six-fold in the 300 to 350 F range, compared to standard untreated kraft insulation.

The new electrical insulation is called Permalex. KEY NO. 609

2. Solventless silicone resin

A new solventless silicone resin

Specify your construction requirements, we can create an ideal tailor-made answer in STAFOAM.

This foamed urethane miracle material is as versatile as the human imagination. Rigid or flexible, film-thin or wall-thick, STAFOAM mixes strength and lightness in unusual proportions; resists ozone, weather, time; fabricates easily.

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Behind STAFOAM and its limitless applications are the Freedlander Laboratories—the nation's largest institution devoted to urethane research and development. Years of specialization of polyurethanes, extensive modern facilities, and an outstanding record of problem-solving are at your disposal when you consider STAFOAM as a possible answer to your construction needs.

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For more information, turn to Reader Service card, circle No. 443

was described by D. P. Huntington of Union Carbide Corp., Silicones Div., 30 E. 42nd St., New York 17.

The experimental resin, called Y-2263, is said to have excellent thermal stability (as measured by elevated temperature craze resistance) combined with low viscosity.

According to Huntington, a significant advantage of the new resin is its ability to be cured at temperatures ranging from 250 to 300 F, compared to conventional silicone resins which require a curing temperature of 480 F.

Huntington says the thermal shock resistance of Y-2263 is good. For example, a molded section of the material withstands 8 cycles between —80 and 400 F before cracking occurs. Huntington says electrical properties of the resin remain fairly constant at temperatures between 75 and 212 F.

The new resin is expected to be used as a transformer impregnant. KEY NO. 610

3. Heat stable organic polymer

Glass fabrics coated with a new, heat stable organic polymer (composition not revealed) show promise for use in high temperature electrical applications. The polymer is called MK by its developer, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Laboratory heat aging tests show that sheet insulation made of MK-coated glass fabric is capable of continuous operation at Class H (360 F) or higher operating temperatures.

According to R. V. Einstman of Du Pont's Fabrics & Finishes Dept., MK polymer has excellent radiation and solvent resistance. Dielectric strength of the material remains constant over the temperature range 77 to 390 F.

Einstman says the polymer may eventually be available in such varied forms as coated fabrics, wire enamel, varnish and fiber, thereby making possible a complete, chemically homogeneous electrical insulating system.

Sample lots of the polymer are available for testing. KEY NO. 611

What's new IN MATERIALS

'Polymorphous' Polyethylene Makes Tough Packaging Films

Three film-grade polyethylene resins have been introduced by Spencer Chemical Co., Dwight Bldg., Kansas City 5, Mo. They are sold under the tradenames Poly-Eth 5305, 5365 and 5375. Density of each is 0.920 gm per cu cm.

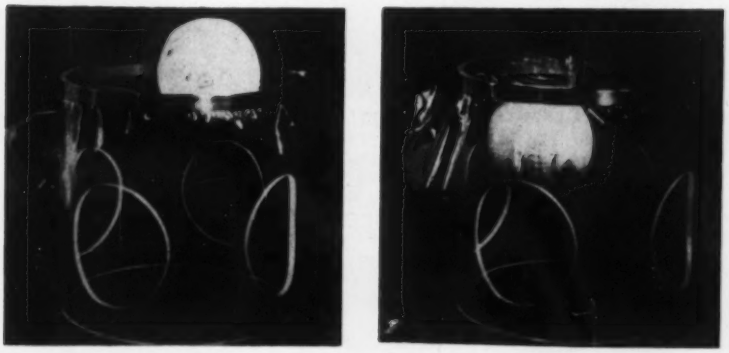
According to Dr. George Ham, plastics technical director, "Spencer has discovered a new process for producing 'polymorphous' polyethylene which makes a general purpose packaging film with unusual strength and clarity."

The process produces a polyethylene in which, according to Ham, the crystals formed during extrusion remain small to give excellent film clarity, and the degree of crystallization remains low to give high strength.

Ham says crystallites (crystals produced in extruding polyethylene resin) remain small because the size of the crystal is restricted by an unusually large amount of highly branched or noncrystalline molecules.

The completely disordered or random placement of the many small crystal elements in polymorphous polyethylene means that the film will not tear in straight lines. A balance of crystalline and noncrystalline molecular elements makes the film tough and impact resistant, according to Ham. KEY NO. 612

'Polymorphous' film *(left) passes the "softball drop test" (commercial standard TS-5438) in which a regulation softball is dropped from a distance of 3½ ft onto a 1½-mil thick film to determine impact resistance. Conventional film (right) fails the test, the softball breaking through the film.*



Enameled Magnesium for Engine Parts, Signs

A porcelain enameling system for magnesium has been developed by Dow Metal Products Co., Div of Dow Chemical Co., Midland, Mich.

The producer says high temperature engine parts, signs, building panels, cooking ware and home appliances are possible applications for porcelain-enameled magnesium.

Key to the new finishing system: a special surface pretreatment that permits the use of standard lead-oxide and lithium-phosphate porcelain enamels on magnesium.

Corrosion resistance

According to Dow, porcelain enameled panels of magnesium AZ31B alloy have withstood 500 hr of 20% salt spray without corrosion. Panels with bared edges showed little edge corrosion.

Panels exposed to exterior weathering in an industrial atmosphere showed no corrosion and no spall back from the bared edges after five months exposure. When the panels were heated to 800 F and immediately quenched in cold water, no spalling resulted.

Limitations

Dow says the new finishing system cannot be used with magnesium alloys of high aluminum content or with alloys of high total alloy content because these alloys contain low melting point eutectic. However, the system has been used successfully

with magnesium alloys of lower aluminum content, the magnesium-thorium alloys, and the magnesium-rare earth metal alloys. KEY NO. 613

Stainless Steel Strip Has Good Workability

A new straight chromium stainless steel strip is now available from Universal-Cyclops Steel Corp., Bridgeville, Pa. It is called Uniloy 435. Big advantage of the strip is that it has better workability in bending and deep drawing operations than type 430 steel. Other properties such as surface characteristics and corrosion resistance are said to be similar to those of type 430.

The stainless strip, composition of which has not been revealed, sells for 42¼¢ per lb. KEY NO. 614

Silicone Dielectrics for Low Temperature Use

The Silicone Products Dept. of General Electric Co., Waterford, N. Y. has introduced two new silicone dielectric greases and a new silicone dielectric fluid. All three materials are designed for both low and high temperature applications.

1. Dielectric fluid

According to GE, the low temperature pour point of the dielectric fluid (<—120 F as determined by ASTM D97-47) makes it especially suitable as a dielectric in extremely low temperature applications.

The material, called SF-85, is designed primarily as a dielectric fluid; however, it may be used as a special lubricant and as a heat transfer medium. Potential applications for the fluid include its use as a dielectric in airborne equipment subjected to both high and low temperatures, and as a dielectric in transformers, capacitors and fluid-filled electronic assemblies. It also has potential use as a heat transfer medium in fluid-cooled electronic assemblies. KEY NO. 615

2. Dielectric greases

The two dielectric greases are designed for use in applications subjected to both low and high temperatures ranging from —65 to 400 F. Both are soft, workable silicone greases that are chemically inert and can be used over a broad PH range.

SS-4005 is designed for general purpose electrical applications. Particularly suited for aircraft, automotive and electronic applications, SS-4005 can be used as a corrosion inhibitor, water repellent seal, insulator, lubricant, and damping and heat transfer media.

XS-4006 is said to be an ideal insulating material for use around copper wire and splices. KEY NO. 616

PROPERTIES OF SF-85

PHYSICAL PROPERTIES	
Viscosity	
Kinematic (77 F), cs	50
Saybolt Universal (100 F)	189
Viscosity-Temp Coef*	0.570
Pour Point, F	<—120
Specific Gravity	0.971
Flash Point, F	600
Specific Heat, Btu/lb/°F	0.374
ELECTRICAL PROPERTIES	
Dielec Str, kv	32.5
Dissipation Factor (10^6 cps)	0.0001
Dielec Const (10^6 cps)	2.75
Vol Res, ohm-cm	1×10^{14}

*Viscosity-temperature coefficient = 1 — (visc at 210 F/visc at 100 F).

Polyester Laminates Have Good Flexibility

Two flexible polyester film products have been introduced by Mica Insulator Div., Minnesota Mining & Mfg. Co., Schenectady, N. Y. for use in electrical and electronic devices.

Laminated sheet: Lamicoid LPF-1 is the name given to the company's new laminated polyester sheet. It consists of two plys of 0.010-in. thick polyester film joined with a special bonding agent. The resulting sheet is said to have good flexibility, high heat resistance, excellent resistance to delamination, and good mechanical and electrical properties. The laminate can be cold formed or punched into a variety of shapes and forms. It is said to have excellent resistance to Freon 22 in sealed systems where no moisture is present. The laminate is presently being used as a U-shaped slot liner in motors.

Copper-clad film: Designated Cu-Flex Lamicoid, the copper-clad polyester film is expected to be used as flexible printed circuits, cables and harnesses. It can be twisted or bent without delamination, according to the producer. The product consists of 1-oz electrodeposited copper foil bonded to either 0.002 or 0.005-in. thick flexible polyester film. KEY NO. 617

New Ferroelectric Ceramics

They are also ferrimagnetic

Scientists at the National Bureau of Standards, Washington 25, D. C., have discovered a series of ceramic materials that show simultaneously both ferroelectric and ferrimagnetic properties. The generalized composition is a barium niobate containing any one of several rare earths plus iron oxide. The composition has a single-phase crystalline structure.

According to R. S. Roth and P. H. Fang of the Bureau's mineral products laboratory, the presence of both rare earths and iron seems to be necessary for the material to show both properties simultaneously. They say the type of rare earth used in the composition has a substantial effect on the Curie point.

Potential uses

According to the Bureau, the barium niobate composition should find use in new electronic components where a coupling between dielectric and magnetic effects is desirable, or where a magnetic material having a high dielectric constant would be useful.

Solid Film Lubricant Used at High Altitudes

A new solid film lubricant—a ceramic-bonded molybdenum disulfide composition—lubricates well at altitudes in excess of 100,000 ft. The lubricant, designated Lube-Lok No. 1005, is now commercially available from Electrofilm, Inc., P. O. Box 106, North Hollywood, Calif.

According to the developer, Lube-Lok No. 1005 lubricates at temperatures up to 700 F in the presence of not more than 1% free oxygen. Other materials, such as organic-

ONE VERSATILE FR-S POLYMER MAKES GOOD IN MORE THAN 500 APPLICATIONS

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bonded solid film lubricants, oil and greases do not lubricate well at high altitudes.

High temperature lubricant

Other work on solid film lubricants done by Electrofilm and discussed by Ralph E. Crump at the 1959 SAE annual meeting includes development of a solid film lubricant for use at temperatures above 1000 F. Crump, noting that molybdenum disulfide oxidizes at temperatures above 800 F, turned his attention to a solid film lubricant containing graphite, lead oxide and porcelain enamel as a binder. The wear life of the porcelain-enamel-bonded graphite-lead oxide composition was the best of six compositions studied. However, Crump says ". . . the compromise of graphite and lead oxide as a solid film lubricant will probably be abandoned in favor of a single solid-film lubricant in a binder."

KEY NO. 618

Coatings, Pellets Indicate Temperatures

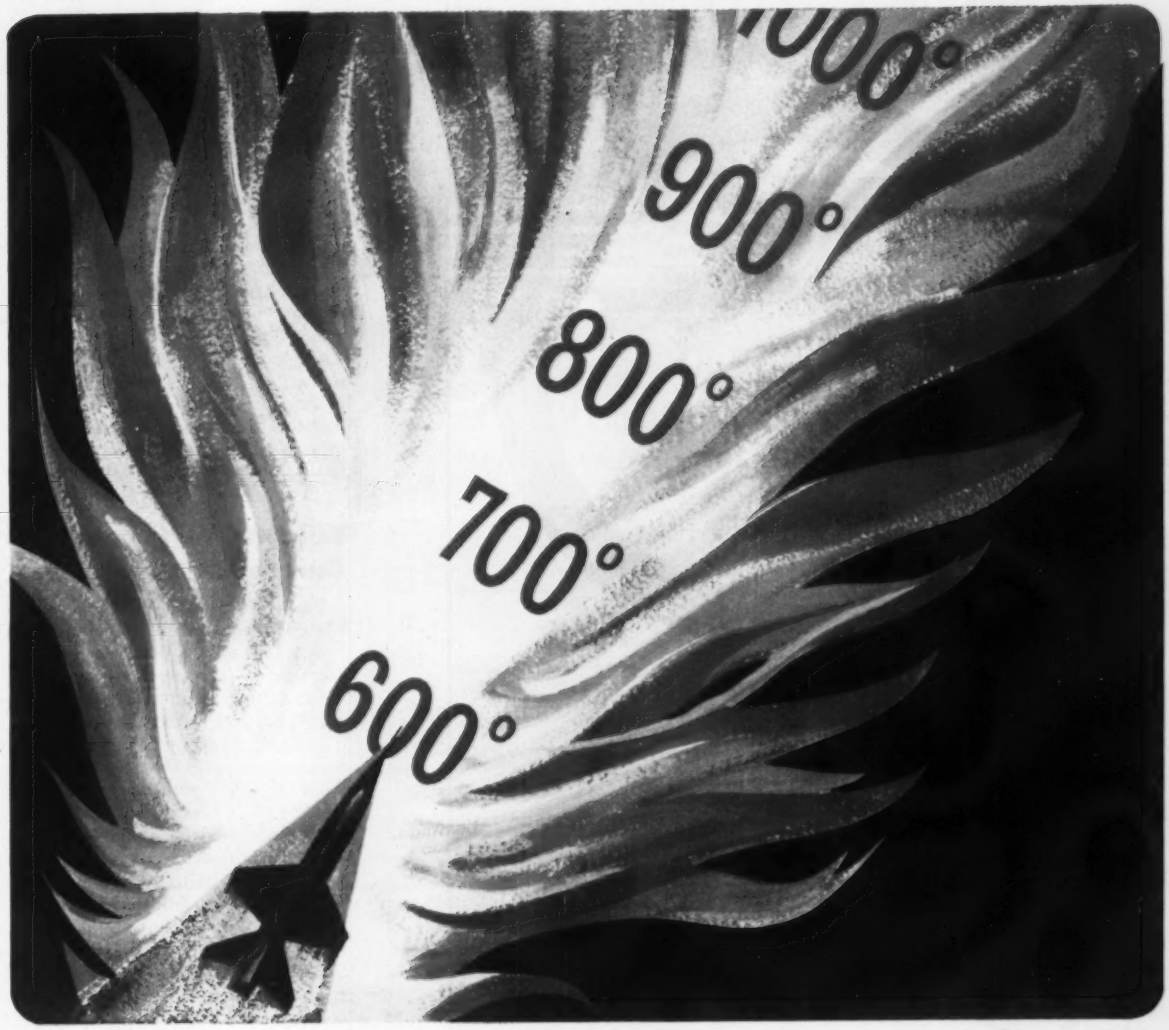
Two companies have introduced new temperature indicating coatings and pellets for use on metals, glass, ceramics and plastics. According to the developers, the coatings can indicate temperatures over the range 100 to 2900 F.

Tempil Corp., 132 W. 22nd St., New York 11 has introduced a temperature indicating coating for use on smooth surfaces such as polished metal, glass, plastics, etc., and on areas that are not readily accessible during heating. The coating, called Tempilaq, is designed for use over the range 113 to 2500 F. The company has also introduced pellets for determining temperatures in the heat treating of large units. The pellets are useful at temperatures from 113 to 2600 F. KEY NO. 619

Curtiss-Wright Corp., Research Div., Quehanna, Pa. has introduced Thermocolor paints for use on metals,

SOURCES of most engineering materials can be found in the third edition of M/DE's *Materials Selector* reference issue, published last October. Properties of all materials are also given.

Experience—*the added alloy in* **Allegheny Stainless**



Easy-to-form metals with high strength up to 1000 F

AM 350 and AM 355, precipitation hardening stainless steels by Allegheny Ludlum have many advantages for designers of missiles and supersonic aircraft in solving space age problems.

Among their many desirable properties, AM 350 and AM 355 combine high hardness and strength and stability up to 1000 F and yet possess good ductility. They are easy to form in the annealed condition.

They can be spun, drawn, formed, machined and brazed or welded using normal stainless steel procedures.

Both steels have excellent corrosion resistance and good resistance to stress corrosion and oxidation at higher strength levels.

AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.**

863

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AND DOES—FOR **AMPHENOL**

PLENCO

phenolic molding compounds

IN MISSILES, in aircraft, in communications, computers, and other electronic equipment, all important *connectors* "hook up" to keep energy on the go. They have to be molded of materials that can stand up to high heat, extreme cold, rough handling.

Amphenol Connector Division of Amphenol-Borg Electronic Corporation, leading U.S. producer of these electromechanical components, finds the answer in the broad selection of Plenco *general-purpose* molding materials.

Plenco 300 G.P., for one. Developed for the widest range of applications and conditions, and specified for Amphenol connectors used by the radio, television, and electronics industry, as well as the military in testing apparatus and transmitting/receiving equipment. To them, Plenco 300 G.P. assures topmost electrical, mechanical, and physical properties.

Ready-made *or* specially-made, Plenco phenolic molding materials have the answer to your product or production requirements. Call on us at any time.

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PLASTIC PRODUCTS

PLASTICS ENGINEERING COMPANY
Sheboygan, Wisconsin

Serving the plastics industry in the manufacture of high grade phenolic molding compounds, industrial resins and coating resins.

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glass and ceramics. The paints are said to indicate temperatures over a range of 100 to 2900 F. Some Thermocolor paints undergo one change, others several changes, in color. The developer says these color changes are not merely slight alterations in shade. Most of the color changes are permanent; thus temperature observations can be made at any time after the conclusion of the test. KEY NO. 620

Silicone Varnishes Cure at 300 F

Class H transformers and other electrical equipment, which are impregnated with silicone varnishes, can now be processed on equipment designed for lower-temperature-curing Class A and B varnishes.

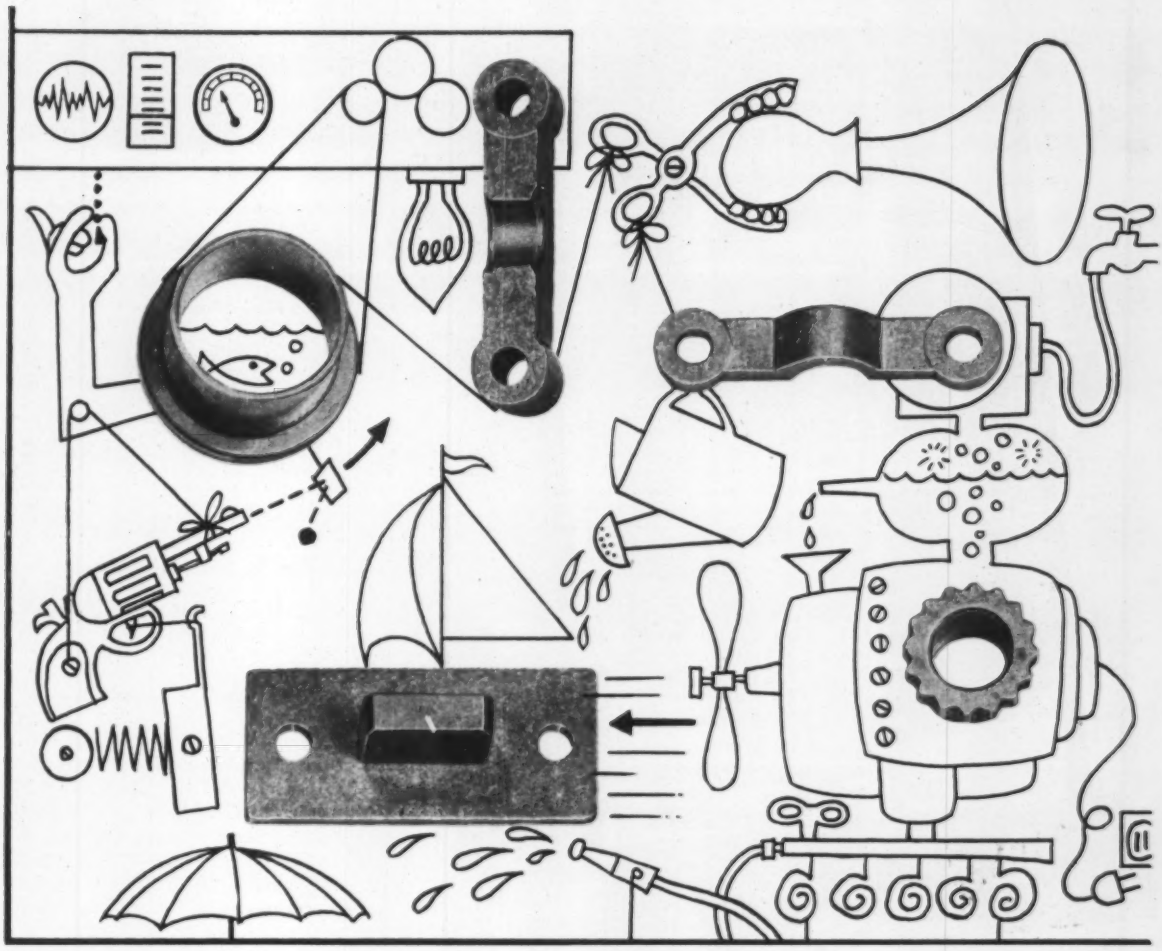
Reason: development of three new silicone varnishes that cure at 300 F. This cure temperature is said to be 120 °F lower than that previously required for Class H silicone varnishes.

No. 980 is the name given by Dow Corning Corp., Midland, Mich. to its new silicone impregnating varnish. The developer says the varnish meets AIEE (American Institute of Electrical Engineers) requirements for use in 430 F (220 C) systems.

The varnish is also said to have greater heat stability than any other varnish. It has good moisture resistance, and good resistance to corrosive environments. Run-off is said to be substantially lower for the new varnish than for other varnishes. KEY NO. 621

No. SR-220 is the name of the new silicone varnish produced by General Electric Co., Silicone Products Dept., Waterford, N. Y. GE says its varnish has good heat life, good tank stability, and excellent shelf life.

Tests show that SR-220 varnish has a significantly higher initial dielectric strength than conventional silicone impregnating varnishes. This high dielectric strength is said to remain relatively constant after heat aging 39 days at 480 F. According to GE, conventional silicone varnishes decrease substantially in dielectric strength after aging at



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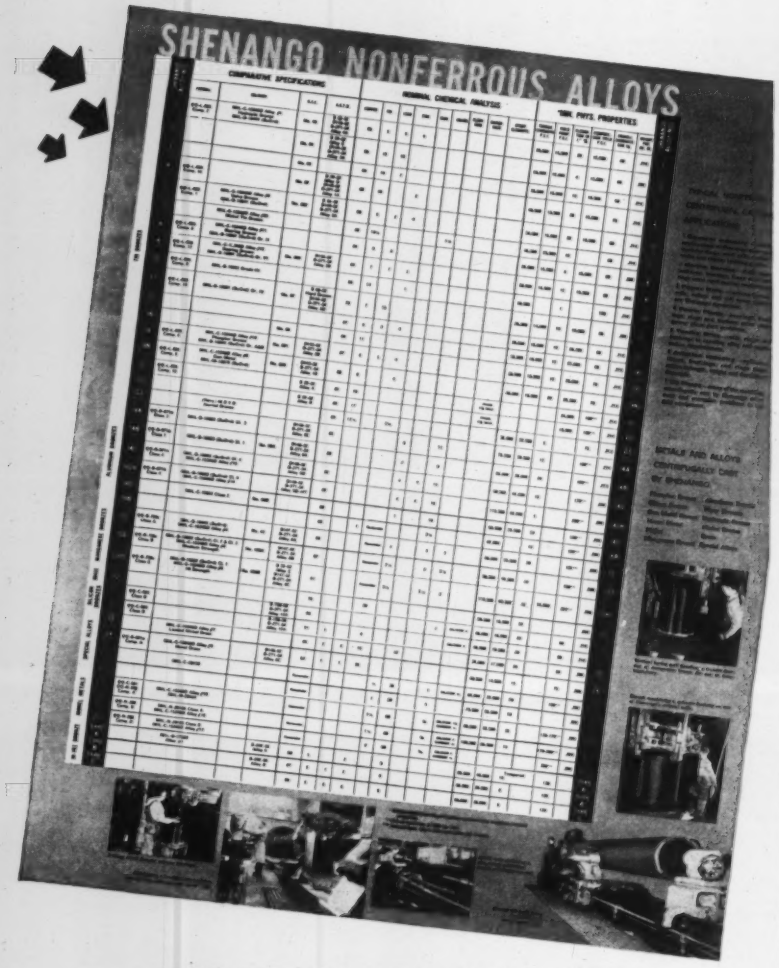

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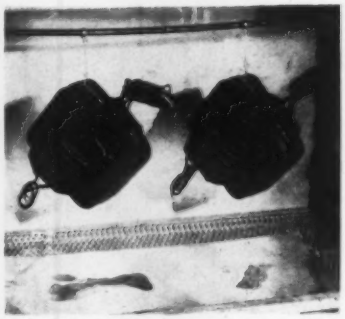
What's new IN MATERIALS



Run-off *of Dow Corning's new silicone varnish (right) is significantly lower than that of conventional silicone varnish (left).*

the same time and temperature.

KEY NO. 622

No. XR-622 is the name given by Union Carbide Corp., Silicones Div., 30 E. 42nd St., New York 17, to its silicone varnish.

According to the producer, the varnish has good thermal stability, low weight loss at high temperatures, and good resistance to moisture and corrosive atmospheres.

Carbide's XR-622 varnish is handled as a 60% solids solution; other silicone impregnating varnishes are handled as 50% solids. The higher solids give good resin build, and permit impregnation of electrical apparatus in a single dip.

KEY NO. 623

Fast Drying Primer Stops Rust Formation

A topcoat can be applied almost immediately over a new rust-proofing primer that air dries to a hard, impact resistant coating in 15 min. Conventional rust-proofing primers usually require a 1 to 3-day drying period before a topcoat can be applied over them.

The rust-proofing paint was developed by Consolidated Chemical & Paint Mfg. Co., Inc., 456 Driggs Ave., Brooklyn, N. Y. It is called Jet-Dri.

According to the developer, a specially formulated pigment in the paint prevents rust from forming on steel and iron by reversing the normal electrogalvanic action that usually oxidizes unprotected iron

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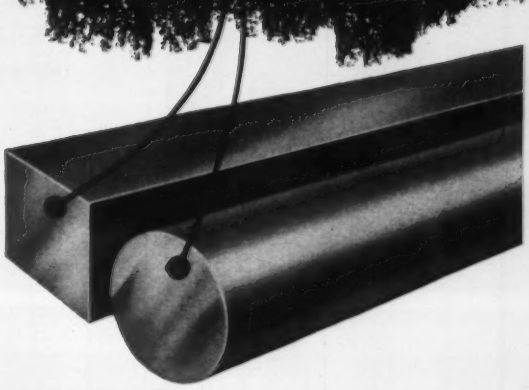
Latrobe's know-how guarantees reliability

Production know-how gained in making highest quality tool and die steels gives Latrobe an advantage in producing VAC-ARC (consumable vacuum melted) steels to meet critical design requirements. VAC-ARC Steels possess unusual cleanliness, improved ingot structure, and superior mechanical properties.



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Bearings	M-50	MV-1
	52100	Regent
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TYPICAL TRANSVERSE TENSILE PROPERTIES
(8" square billet of Dynaflex)

Property	Mid-Radius		Center	
	Air Melt	Vac-Arc	Air Melt	Vac-Arc
Tensile Strength (psi)	285,000	287,000	285,000	285,000
Yield Strength .2% (psi)	250,000	252,500	245,000	250,000
Elongation %	4	8	2.5	8
Reduction of Area %	10	25	3	24

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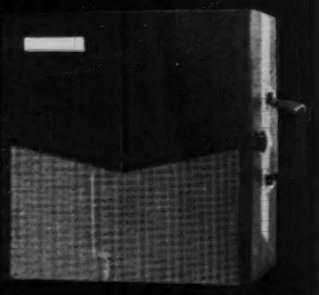

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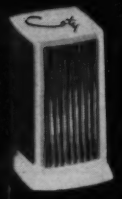

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For more information, circle No. 348

What's new IN MATERIALS

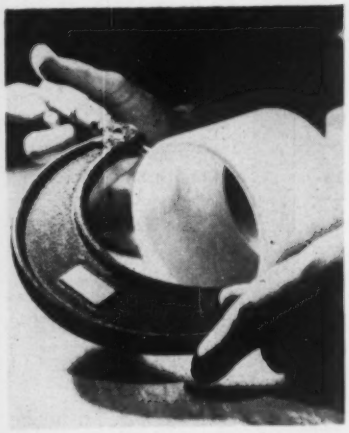
and steel when in contact with air. In addition to iron and steel, the paint can be applied over wood, plaster and other porous materials. It is said to be resistant to most acids, alkalis, alcohol and boiling water. KEY NO. 624

Two Silicone Rubbers for Wire Insulation

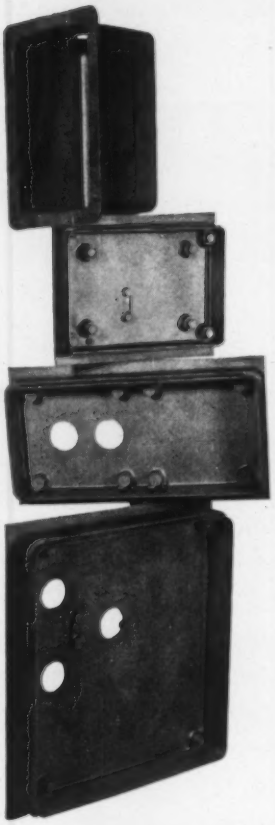
Silicones Div., Union Carbide Corp., 30 E. 42nd St., New York 17 is offering two new types of low shrink silicone rubbers for cable and wire insulation.

K-1347 is described as a premium-grade material with superior physical and electrical properties. It can be continuously vulcanized on conventional equipment with either steam or hot air. It is supplied in sheet form.

K-1357 is said to be a moderately



Beryllium oxide ceramic — The vacuum tube envelope shown here is made out of a new beryllium oxide ceramic specially processed for such applications. The material is said to be vacuum-tight and free of outgassing. It has a surface especially well suited to metallizing. The ceramic was developed by National Beryllia Corp., 4501 Dell Ave., North Bergen, N. J. Called Berlox EM, the material is available in the form of rods, tubes, cylinders, and bulk shapes such as blocks and plates, plain or machined to specifications. KEY NO. 625



Aluminum cans for electronic applications are cast accurate, smooth and pressure tight by the unusual foundry methods of Morris Bean & Company, Yellow Springs 1, Ohio.

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For more information, circle No. 401

stitching together a giant radome

Radome designed and built by Long Sault Woodcraft Limited, St. Andrews East, Quebec, for the United States Air Force RADC.

Looking upward from the inside of the world's largest stressed skin sandwich radome built of translucent fiberglass panels, securely joined by hundreds of DUAL-LOCK fasteners.

Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

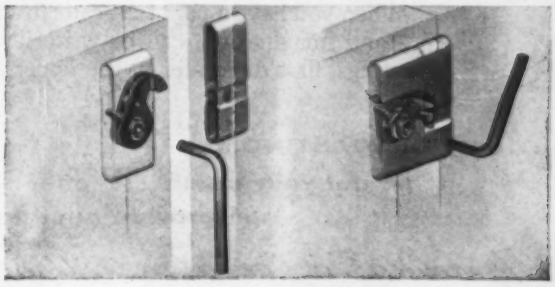
This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
- Double-acting take-up provides great closing pressure, with minimum pressure on operating tool.
- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

Write for catalog #1257. Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



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Tape recorder flywheel demands

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Sometimes it takes a design engineer or a die caster to appreciate a part.

Take this flywheel for a well-known tape recorder. Few applications demand such exactness in balance. Improper weight distribution in the casting would *insure* improper recording.

Yet, by its own method, Twin City Die Castings delivers flywheel after flywheel in proper balance.

Sometimes a job demands die casting *plus* an imaginative application of the process.

When you have a part that calls for *both* die casting and imagination, call or write Twin City Die Castings, first die caster in the upper midwest.

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What's new IN MATERIALS

priced material with good electrical and physical properties. It is available in coiled strips for direct feed to an extruder. It can be cured in either steam or hot air. KEY NO. 626

Metallized Paper May Compete with Foil

Economical, vacuum deposited aluminum coatings on paper are beginning to appear and will be in general use within two years, says K. C. Taylor of F. J. Stokes Corp., Philadelphia 20. Taylor, speaking at a recent TAPPI (Technical Assn. Paper & Pulp Industry) meeting, says a low cost method of precoating paper to reduce out-gassing and to provide a smooth base for the aluminum coating still has to be developed.

The goal is to produce a metallized paper product with the approximate reflectivity of laminated aluminum foil at 60% of the cost of aluminum foil. This product would maintain the many advantages of an all paper product.

Taylor says promising precoatings now being evaluated include completely stable lacquers and plastics films. One big drawback with plastics films, says Taylor, is the fact that the films alter ink reception, machine folding and weight yield. He says specialized clay coatings will have to be used as a base for metallized coatings if extensive printing is going to be accomplished on metallized paper. KEY NO. 627

Black Glass Protects Semiconductor Devices

A scratch-resistant black glass that is impervious to light has been designed for enclosing light sensitive silicon semiconductor devices. The glass is said to filter out virtually all wavelengths of the ultraviolet, visible and near-infrared spectrum.

The glass was developed by Corning Glass Works, Corning, N. Y. It is called Code 9361.

According to Corning, the glass has physical properties similar to those of standard clear glass now used for enclosing semiconductor de-

new FF-60 reduces moisture problem

FF-60 Electrical Properties

	Dielectric strength (step by step) v/mil
Cond. A	450
Cond. D48/50	400
Insulation resistance, C96/35/90, megohms	20,000

Formica FF-60, new glass melamine laminated plastic designed to meet the new Mil Specs for type GME, retains many times the dielectric strength of NEMA G-5 after prolonged exposure to moisture! It also offers superior craze resistance and excellent heat-, arc- and fire-resistance.

It is well suited for use in circuit breakers, switch bases, in shipboard power generation and distribution systems – and in similar military and commercial applications requiring the most dependable electrical insulation in moist conditions.

Test FF-60 yourself. Write for free sample and data sheet. Formica Corporation, a subsidiary of American Cyanamid, 4550 Spring Grove Ave., Cincinnati 32, Ohio.

FIF

FF-60 parts *fabricated better, faster – 24 hours in some cases . . . by your local Fabricator of Industrial Formica laminated plastics . . . who also stocks FF-60 and other standard sheets for immediate delivery. Consult telephone directory, SWEET'S Product Design File, Thomas' Register or McRae's Blue Book for the FIF fabricator nearest you.*

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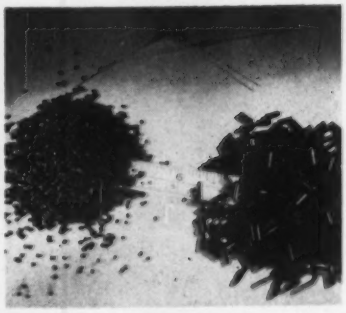
What's new IN MATERIALS



Beads and cases *made of black glass are used to protect silicon semiconductor devices against light.*

vices. It has a coefficient of thermal expansion of 51 x 10^{-7} per °F, a softening point of 1250 F, an annealing point of 925 F, and a strain point of 850 F.

The new material is supplied in the form of beads measuring 0.053 in. o.d. by 0.023 in. i.d., and in the form of cases measuring 0.095 in. o.d. by 0.060 in. i.d. Tolerances for both beads and cases are ±0.002 in.

KEY NO. 628

Bright Copper Plating

A new bright copper plating process, called Copper-Lume, is said to have the following advantages:

1. Smooth, bright deposits over wide temperature and current density ranges.
2. Good metal distribution.
3. Easy-to-operate bath.

The copper plating process was developed by Hanson-Van Winkle-Munning Co., Church St., Matawan, N. J. KEY NO. 629

SBR Rubber Cures Fast, Resists Abrasion

Goodrich-Gulf Chemicals, Inc., 3121 Euclid Ave., Cleveland 15 has developed a new, fatty-acid-emulsified, cold-type SBR rubber called Ameripol 4600.

According to the developer, the new synthetic rubber cures faster and has less tack than conventional type 1502 SBR rubber. Tests show Ameripol 4600 has higher modulus than 1502, but is equal in abrasion

For more information, turn to Reader Service card, circle No. 421

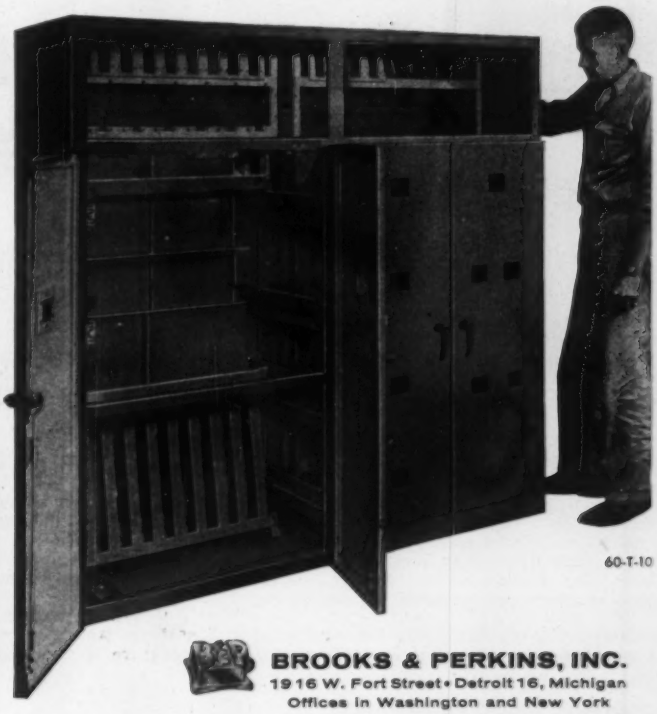
B & P Precision Cabinets and Consoles for Missile System Ground Support Equipment

Cabinets and consoles for electronic and fire control equipment are important elements of ground support equipment in every missile and radar system.

For many years B & P has made cabinets for Nike and other missile systems. These precision cabinets, of magnesium or aluminum, are made as arc-welded assemblies. Special techniques have been developed to prevent distortion during welding. Every cabinet is stress-relieved after welding.

Of the thousands of cabinets and consoles built by B & P, all have been held to close dimensional precision.

When you need lightweight electronic cabinets and consoles, think first of B & P, the most experienced builder of precision light metal electronic ground support equipment cabinets. For more complete details, write to B & P, Detroit.



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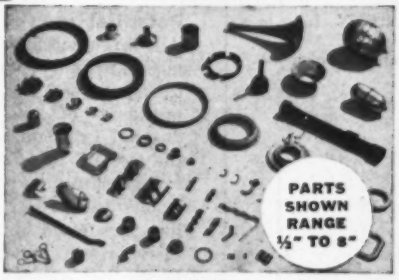

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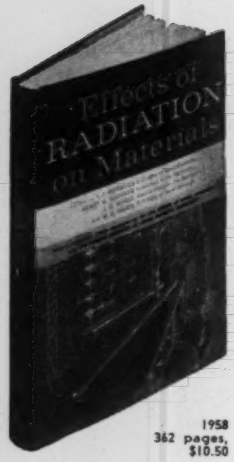

1958
362 pages,
$10.50

Effects of RADIATION on Materials

Edited by **J. J. HARWOOD**, U. S. Office of Naval Research; **HENRY H. HAUSNER**, Consultant to The Martin Co.; **J. G. MORSE**, Nuclear Div., The Martin Co.; and **W. G. RAUCH**, U.S. Office of Naval Research

The changes that radiation produces in metals, ceramics, plastics and a wide variety of other materials are thoroughly covered in this momentous new book. It contains the papers delivered at the radiation effects colloquium jointly sponsored by the Office of Naval Research and The Martin Company at Johns Hopkins University in March 1957.

Twelve leading authorities analyze the results of their own actual experiments with various materials. Solid state physicists classify fundamental and qualitative effects according to type. Metallurgists and chemical engineers make a quantitative evaluation of radiation effects on physical properties. The book also includes current concepts of radiation effects and discusses experimental approaches to radiation studies.

The outstanding authorship, and the subject's timeliness and importance establish this book as a milestone in technical literature. An extensive bibliography brings together the enormous amount of literature on the subject from every part of the world.

CONTENTS AND CONTRIBUTORS:

Defects in Solids and Current Concepts of Radiation Effects—G. J. DIENES, Brookhaven National Laboratory.
Experimental Approaches to Radiation Studies—Radiation Sources and Desimetry—J. C. WILSON, Oak Ridge National Laboratory.
Radiation Effects on Physical and Metallurgical Properties of Metals and Alloys—E. S. BILLINGTON, Oak Ridge National Laboratory.
Influence of Radiation Upon Corrosion Behavior and Surface Properties of Metals and Alloys—M. SIMNAD, General Atomics.
Effects of Radiation on Electronic and Optical Properties of Inorganic Dielectric Materials—R. SMOLOCHOWSKI, Carnegie Institute of Technology.
Effects of Radiation on Semiconductors—H. Y. FAN and K. LARK-HOROVITZ, Purdue University.
Cores, Liquid Coolants and Control Rods—C. E. WEBER, General Electric Co. (Knolls Atomic Power Laboratory).
Moderators, Shielding and Auxiliary Equipment—G. R. HENNIG, Argonne National Laboratory.
Experimental Techniques and Current Concepts—Organic Substance—M. BURTON, University of Notre Dame.
Effects of Radiation on Behavior and Properties of Polymers—A. CHARLESBY, Tube Investments Ltd., Cambridge, England.
Kinetics of the Gamma-Induced Graft Copolymerization of Vinyl Acetate to Teflon—A. J. RESTAINO, Nuclear Div., The Martin Co.
Bibliography—H. FRIEDEMANN.

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What's new IN MATERIALS

PROPERTIES OF SBR RUBBERS COMPARED*

Type→	1502	4600
Tensile Strength, psi	3065	3090
Elongation, %	775	740
Modulus (300 %), psi	540	630
Hardness (Shore A)	58	60

*Stocks reinforced with 40 parts (per 100 parts rubber) channel black, and cured 50 min at 292 F.

resistance, rebound and hysteresis.

The new material is expected to be used in sponge, household goods, white sidewalls, floor tile and shoe soles. **KEY NO. 630**

Tough Urethane Film Resists Abrasion, Ozone

A new urethane film is said to be three to five times stronger than other materials commonly used for films. It is also said to be practically unaffected by ozone, and to resist abrasion better than steel.

The material used in the film, Estane VC, was introduced recently by B. F. Goodrich Industrial Products Co., Div. of B. F. Goodrich Co., Akron, Ohio (see M/DE, May '59, p 168).

Estane VC is described as a tough, resilient urethane elastomer that snaps back like rubber yet, unlike rubber, can be used without vulcanization.

Potential uses

A large potential use for the film might be unsupported, flexible gas tanks, says J. C. Richards, vice president of the company's Industrial Products Div. He says that the use of the film for gas tanks could inspire major changes in automobile design. For example, a sack-like tank could be made to conform to any open space in a car, even under the fenders. Total car weight

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Cold Resistance	**down to —135° F.**
Chemical Resistance	**over 600 deg. F. range**
Dielectric Properties	**as required**
Strength Combinations	**shear, tensile, elongation**

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1533A-1

COLONIAL RUBBER CO.
RAVENNA, OHIO

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Titanium powder now economically formed into strong, lightweight, corrosion-resisting parts

Titanium has entered still another fabricating field . . . powder metallurgy . . . that adds to its growing usefulness in the chemical, processing, and other industries.

Today you can design titanium parts to be formed by powder metallurgy techniques that combine strength, purity and corrosion resistance equal to wrought titanium. Close tolerances permit a minimum of machining on contacting surfaces; none on non-contacting surfaces. An example is the chemical valve seat, above, made by Clevite Corporation of Cleveland, Ohio.

Finished parts weighing from less than an ounce up to many pounds are being produced. Shape can range from simple gear or cam blanks to complex pieces with wide variation in cross-section. Titanium powder metal parts compare favorably in cost with wrought and machined parts.

To learn more about the growing use of titanium powder metallurgy for corrosion-resisting, light, strong parts, write us. Union Carbide Metals Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto.

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For more information, turn to Reader Service card, circle No. 437

and production costs could be lowered by eliminating the manufacturing operations necessary in making metal gasoline tanks.

Richards explained that the plastic film is unaffected by gasoline and other petroleum products. The thin, tough material not only lends itself to stitching, but also can be sealed to itself electronically or by heat sealing to form a leakproof cell. Experimental tanks have already passed rigid tests, according to Goodrich.

Other potential uses for the film include coated fabrics, electrical insulating tape, unsupported upholstery film, awnings and tarpaulins, luggage covering, bathing caps, and gloves. (For more detailed information on the properties and uses of solid urethane elastomers see M/DE, Oct '59, p 92.) KEY NO. 631

Other News . . .

Metals

▸ A high purity indium ingot is available in 10 and 100-troy-oz sizes from High Purity Metals, Inc., 340 Hudson St., Hackensack, N. J. Three ranges of purity are available: Type A (99.9%), Type B (99.99%), and Type C (99.999%). KEY NO. 632

▸ Olin Mathieson Chemical Corp., 460 Park Ave., New York 22 has added heat treated aluminum sheet to its product line. KEY NO. 633

▸ Carbon and low alloy stainless steel wires are being wound into porous, hollow cylinders and cones for use in fluid filtration. The porous metal shapes, called Poroloy CS, are available from Bendix Aviation Corp., Filter Div., 434 W. 12 Mile Rd., Madison Heights, Mich. The filters can be used in moderately corrosive atmospheres at temperatures up to 400 F. KEY NO. 634

Plastics

▸ An extruded, medium impact styrene sheet for use in lighting fixtures and indoor displays is being marketed by Cadillac Plastic & Chemical Co., 15111 2nd Ave., Detroit 3. The light-stabilized styrene is supplied in flat and corrugated sheets. KEY NO. 635

▸ Clear polyester sheets in thicknesses up to ½ in. are now avail-

A. High-Pressure Gas Cylinder, 3⅜" D. x 18⅞"
B. High-Pressure Gas Cylinder, 3⅛" D. x 7⅝"
C. Jato Motor
D. Jato Shells to 20" D. x 60"
E. Falcon Rocket Motor Case
F. Jato—approximately 9" D. x 30"

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Hackney methods offer designers plenty of latitude. Units can be made in sizes from 1 quart to 100 gallons. Diameters range from 3" to 32". Lengths may be from ½ to 5 times the diameter, or up to 110". Wall thicknesses—.050" to .670". Working pressures—up to 600 psi in larger diameters, 6000 psi in smaller diameters. And our dies and mandrels can form your components in steel, magnesium, nickel, the new ultra-high strength stainless steels, hot work tool steels, molybdenum or titanium.

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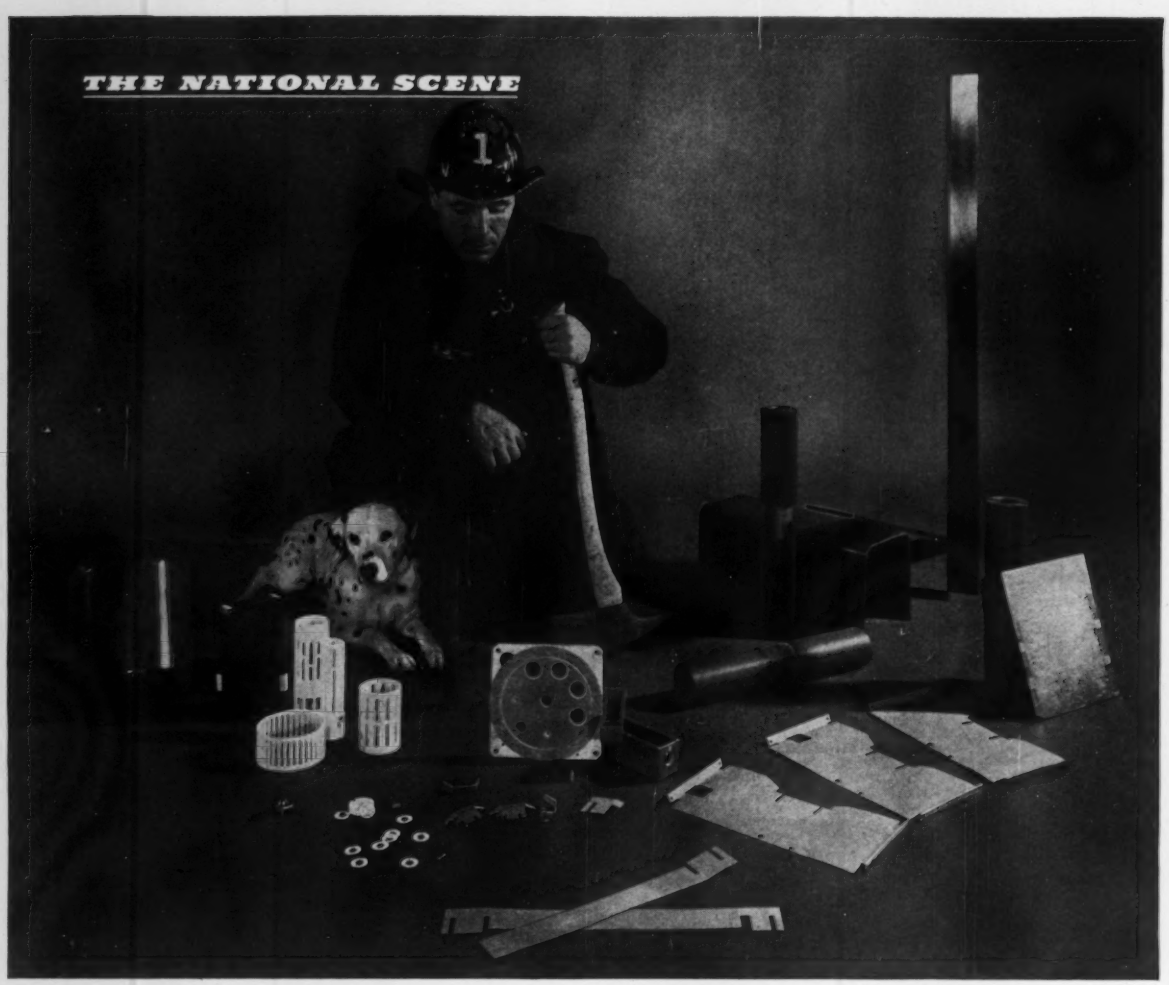


"Where can flame-retardance improve your product; make it safer . . . function better . . . or sell faster?"

Choose from 11 National Materials—in sheets, tubes, rods, formed shapes, or precision-fabricated parts

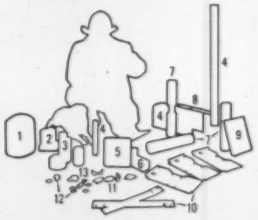
Computers, high-voltage switchgear, home appliances, television receivers, radios and radar . . . aircraft and missile instrumentation . . . in fact, with any product where fire is a potential, flame-retardant laminates pay-off in design features and product protection.

The "pay-off" comes in protection of lives and expensive equipment from fire, because these materials are self-extinguishing. As barriers, base plates, terminal boards, support members, printed circuits—National's family of flame-retardant materials is solving problems of fire containment and those involving *both* fire and electrical insulation.

Surprisingly, *low cost* is a feature of several of these materials. And since they mean more safety and product protection for the user, the "pay-off" also comes in the form of added product sales features.

Write for complete property values on these eleven materials, and let us know what your particular problem is. If you wish samples and price information, drop us a note on your letterhead. National Vulcanized Fibre Co., Dept. KK-3, Wilmington 99, Delaware.

Grade	Base	Resin	Extinguishing Time (sec.) UL
PYRONIL	Cellulose	None	<1
X-121	Paper	Phenolic	2-4
X-122	Paper	Phenolic	1
XX-326	Paper	Phenolic	1½-2
XXXP-475	Paper	Phenolic	<1-1½
GP-9202	Glass Mat	Polyester	<1
GP-9204	Glass Mat	Polyester	<1
G-5-813	Glass Cloth	Melamine	<1
G-7-832	Glass Cloth	Silicone	<1
GH-871	Glass Cloth	Phenolic	<1
EP-491	Paper	Epoxy	<1



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Extruded Nylon: 2 grades; rod, strip, pressure tubing, special shapes.

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NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

What's new IN MATERIALS

able from Thermacote Co., 108 S. De Lacey Ave., Pasadena, Calif.
KEY NO. 636

▸ Diallyl phthalate molding compounds are now commercially available from Rogers Corp., Rogers, Conn. **KEY NO. 637**

Other nonmetallics

▸ Emerson & Cuming, Inc., 869 Washington St., Canton, Mass. has introduced a ceramic foam for use as microwave components. The foam, called Eccosorb BR, is available in sheet form. It weighs approximately 20 lb per cu ft. **KEY NO. 638**

▸ A self-lubricating bearing made of molybdenum disulfide, bronze and TFE resin has been designed for low temperature applications. The bearing is said to operate over the temperature range —300 to 500 F. The bearing, called Sinitex, is available from Booker-Cooper, Inc., 6940 Farmdale Ave., North Hollywood, Calif. **KEY NO. 639**

Finishes

▸ A three-step process for silver plating aluminum bus bars has been developed by Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. Degreased bus bars are treated in 1) an alkaline bath, 2) a mercuric compound bath, and 3) a silver plating bath. **KEY NO. 640**

▸ A white epoxy coating for tooling applications can be applied "paper thin" or built-up to a thickness of ⅛ in. The coating is called PR-1125. It was developed by Ren Plastics, Inc., 5422 S. Cedar Rd., Lansing 9, Mich. **KEY NO. 641**

▸ A chlorinated rubber-base paint is said to be highly resistant to moisture, humidity, salt spray, acids and alkalis. Called Parifco, the paint was developed by Industrial Finishes Co., Inc., 1119 Land Title Bldg., Broad & Chestnut Sts., Philadelphia 10. **KEY NO. 642**

Testing equipment

▸ A new light transmittance meter is said to record the clarity of polyethylene films without human error. The instrument, developed by U. S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., 99 Park Ave., New York 16, determines the relative amount of light transmitted through a film specimen at essentially a zero angle of scatter. **KEY NO. 643**

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Prices of Materials

Changes since last semi-annual report in September are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.68	—
Butadiene-Styrene	.14-.30	.26-.54
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.50
Silicone[a]	1.90-4	—
Polysulfide[a]	.50-.125	.80-.125
Urethane	1.15-1.65	—
Natural[b]	.41	.47

[a]Less than carload quantities.
[b]Average spot price for month of November.

REINFORCED PLASTICS LAMINATE SHEET

Type	0.025-¼ In.	⅛-2 In.
Paper-Base Phenolic (X, P, PC, XX, XXP, XXX, XXP)	1.03-1.50	.82-1.22
Cotton Fabric-Base Phenolic (C, CE, L, LE)	1.20-2.20	1.36-1.76
Asbestos-Base Phenolic (A, AA)	1.20	.96-2.70
Glass-Base Phenolic (G-3)	3.25	2.60
Glass-Base Melamine (G-5)	2.88	2.30
Glass-Base Silicone (G-7)	6.65	5.90
Nylon-Base Phenolic (N-1)	4.43	3.54

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.43-.60	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.35	.17-.34
Polyester	.31-.39	.33-.53
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.34	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compound: Base	Molding Compound: Per Cu. In. As Molded, ¢[a]	Sheet (.030-.250)	Rod (⅛-¼)	Tube (⅛-¼)
Acetal	.88	4.6	—	—	—
Acrylic	.55-.59	2.2-2.4	.49-2.15	.90-1.15	1-1.15
Chlorinated Polyether	3.50	17.8	—	—	—
Cellulosic					
Acetate	.36-.58	2.1-2.8	.92-1.16	.75-1	.85-1
Butyrate	.40-.62	2.0-3.0	1-1.28	.95-1.20	1.05-1.20
Nitrate	—	—	1.60-2.73	1.45-1.75	2.25-5.00
Propionate	.62	2.7	—	—	—
Fluorocarbon					
CFE	7-8	53.0-61.0	15-23	18-22	20-22.50
TFE	**3.60-5.65**	27.2-47.0	**14-11**	13	13
Nylon	1.18-2.18	5.0-9.0	—	3	3
Polycarbonate	2.35-2.75	10.0-12.0	—	—	—
Polyethylene	**.32-.38**	1.1-1.3	.85-1	.75-1	.85-1
Polypropylene	.49-.58	1.6-1.9	—	—	—
Polystyrene	**.22-.43**	0.88-1.7	.57-.61	.65-.90	.75-.90
Vinyl	.24-.43	0.10-2.4	.62-.92	.75-1	.85-1

[a]Cost of base molding compound in ¢/lb divided by molded specific volume in cu in./lb.

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.26
Ingot (99-99.9%)	.28
Foil (5-0.5 mil)	.58-.59
Alloy Ingot (13, 43, A132, 214)	.30-.33
Sheet (1100, 3003; 3-0.03 in.)[a]	.48-.56
Plate (1100, 3003, 5050, 3004, 5052)[a]	.45-.53

[a]Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.51	.54	.55
Seamless Tubing	.54	.57	.58
Rod (not f.c.)	.50	.53	.54
Wire	.51	.54	.55

COPPER

Ingot (elec)	.35
Sheet, Strip (hot rolled)	.52-.57
Seamless Tubing	.58
Rod, Drawn	.54
Wire	
Round	.38
Square, Rectangular	.42
Magnet	.44

LEAD

Common Grade	.12

MAGNESIUM

Pig (98.8%)	.35-.36
Ingot (98.8%)	.36-.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41

NICKEL

Form	"F"	"A"	Monel
Ingot	.79	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.38	1.20
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

TIN

Straits[a]	1.03

[a]Spot.

continued on p 212

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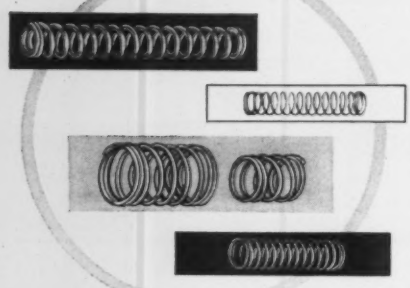

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Bars, Rod	4.00-6.25
Plate	5.25-10.00
Sheet, Strip	7.25-17.00
Wire	5.55-9.50

ZINC

Prime Western	.13
Die Casting Alloys[a]	.17
Sheet	.28
Ribbon	.23
Plates	.22

[a]Alloys 2, 3, 5.

NONFERROUS POWDERS

Aluminum [a,b]	.39
Brass[a]	.35-.52
Copper (elec or red.)[a]	.44
Molybdenum (98%)	3.15-4.10
Nickel	1.15
Tantalum	30
Tungsten (C-red. 98.8%; H_2-red. 99+%)	3-4[c]
Zirconium	
Flash Grade	4
Electronics Grade	15

[a]Price for —100 mesh. [b]Freight allowed. [c]Delivered price.

OTHER NONFERROUS METALS

Cadmium (bars)	1.50
Columbium	55-85
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34-.38[a]
Palladium	$24-26/troy oz
Platinum	$82-85/troy oz
Silver	90-91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium (90%)	3.65
Zirconium (sheet, strip, bar)	20-30

[a]Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	82
Billets, Blooms, Slabs	
Carbon, Re-Rolling	80
Carbon, Forging	99.50
Alloy, Forging	119
Seamless Tube Rounds	122.50
Wire Rods	$6.40/cwt

(continued on p 214)

Design properties of elastomer coatings of Du Pont Fairprene®

These nine coating materials represent a remarkable range of heat, chemical and solvent resistance

An exclusive calendering-coating process at Du Pont creates exciting design materials from elastomer and fabric. Special coatings are combined with selected fabrics to produce materials with many variations in chemical and physical properties. The many synthetic-rubber coating materials available from Du Pont are tabulated below with their advantages for "Fairprene" coated fabrics.

Butyl rubber has outstanding resistance to permeability of most gases. It has excellent electrical properties and resistance to corrosive chemicals, vegetable and mineral oils, acetone, alcohol, phenol, ethylene glycol and water. It resists abrasion and outdoor exposure.

GR-S—This general-purpose synthetic rubber stands up well to abrasion, heat and aging. It has about the same resistance to solvents, chemicals and outdoor exposure as natural rubber.

Hycar PA—Service-temperature range is from 0°F. to 300° F., and it has good resistance to oxygen, ozone and sunlight. Most common applications are where exposure to hot hydraulic fluids and oils is expected.

"Hypalon"*—This material has outstanding resistance to ozone and oxidizing chemicals as well as abrasion, weather and flex cracking. It is heat-resistant to 350°F. and can be compounded for good low-temperature flexibility, low moisture absorption, good electrical properties and flame resistance. "Hypalon" coatings can be produced in a wide range of stable colors.

Neoprene has excellent resistance to oils, aliphatic hydrocarbons, corrosive chemicals, ozone and weather. It is heat-resistant to 250°F.

Buna-N—Properties include excellent resistance to mineral oils, aromatic hydrocarbons and solvents, and vegetable oils. Buna-N has good heat resistance and resistance to non-oxidizing acids and bases. The polymer can be plasticized for good low-temperature flexibility.

Silicones have outstanding high-temperature resistance plus low-temperature flexibility. They have high resistance to oxidation, ozone and corona.

"Thiokol" polysulfide rubber has outstanding resistance to swelling in oils, greases, aromatics and solvents. Most common use is for gas-meter-bellows construction.

"Viton"*—This fluorocarbon elastomer has exceptional high-temperature serviceability—from –40°F. to as high as 600°F.—combined with outstanding resistance to oils, fuels, aromatics, solvents and chemicals.

Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products or improving present ones. For information and your copy of Du Pont's free fabrics manual, mail coupon or write: E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division MDE-03, Wilmington 98, Delaware.

*Du Pont's registered trademarks.

FREE COATED FABRICS MANUAL

12-page booklet describes in detail all basic specifications, properties, uses and performance characteristics for "Fairprene" coated fabrics and cements. Mail coupon or write Du Pont . . . there's no obligation.

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Fabrics Division MDE-03, Wilmington 98, Delaware

Please send FREE information on: ☐ **"Fairprene" coated fabrics.**

☐ **Du Pont technical service.** I am interested in using a coated fabric for_____

Name_____ Position_____

Company_____

Address_____

City_____ Zone____ State_____

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PRICES & SUPPLY

FINISHED STEEL (¢/lb)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.30	7.95	7.50
Sheet, HR	5.10	7.52	—
Sheet, CR	6.27	9.27	—
Strip, HR	5.10	7.57	8.40
Strip, CR	7.42	10.80	—
Bar, HR	5.67	8.30	6.72
Bar, CF	7.65	—	9.02

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.39-.50	.46-.50	.41-.46	.51-.57
321[a]	.49	.58	.55	.66
347[a]	.58	.67	.65	.79
Martensitic				
410[a]	.29	.35	.30	.40
416	.30	.36	.31	.48
403	.29	.35	.30	.40
420, 440	.36	.43	.40	.62
Ferritic				
405, 430, 430F[a]	.31	.36-.37	.31-.33	.47-.52
442	.33	.40	.37	.56
431	.39	.46	.41	.56
446	.41	.48	.43	.70
High Mn				
202[a]	.38	.45	.40	.49
Extra Low C				
304L	.50	.57	.54	.63
316L	.72	.84	.80	.89
Precip Hard.				
17-7PH	.69	.76	.85	.90
PH 15-7 Mo	.89	.97	1.11	1.16

[a]Ingot price approx 60% of billet price.

FERROUS POWDERS ($/lb)[a]

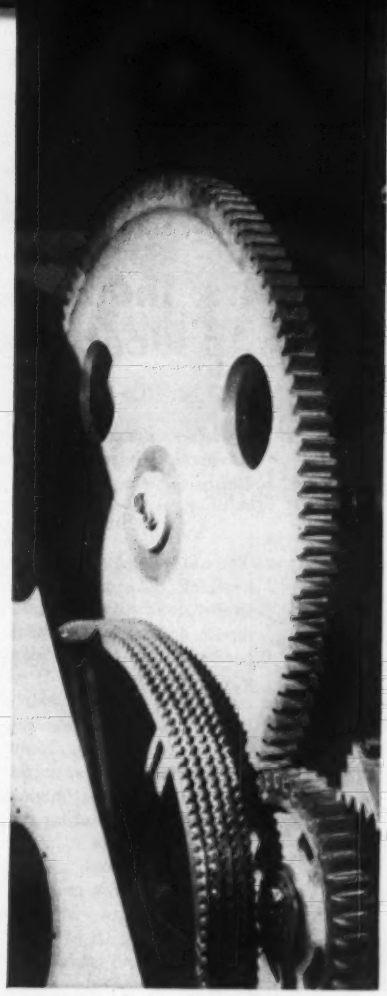
Sponge Iron	.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.33
Stainless Steel	
304	.89
316	1.26

[a]Price for —100 mesh.

IRON ($/gross ton)

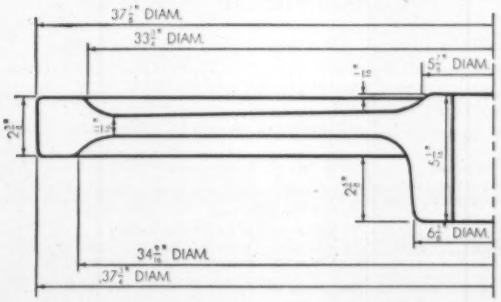
Pig	66-67

(continued on p 216)



GEAR *installed in hoist mechanism of Koehring Company power shovel.*

EXCELLENT *response to induction hardening? Take a look!*



This gear now costs $35.24 less,

THANKS TO BETHLEHEM CIRCULAR FORGINGS

"We are also very pleased with product machining properties, freedom from defects in the tooth area, and excellent response of the forging to heat treatment."

KOEHRING COMPANY, MILWAUKEE, WISCONSIN
manufacturers of construction equipment

Koehring Co. previously machined this gear from a cast gear blank. Today they machine it from an impression-die steel forging made on Bethlehem's unique Slick Mill. They save $29.24 in first cost, plus $6.00 in machining costs! (Turning, boring, facing, and hobbing teeth.)

Here's how we do it

The answer, of course, lies in Bethlehem's Slick Mill—the only one of its kind in the country. Quick die set-up (only 15 minutes)—quick operation (just one minute to forge and roll a circular product)—low die charges (⅓ to ½ less than conventional impression dies)—and less steel needed (utilizing the principle of forging design, the Slick Mill can produce lighter-weight sections without sacrificing strength) . . . all these add up to important savings. At the same time, the process insures *soundness, excellent grain flow,* and *machinability.*

Bethlehem's Slick Mill saves the Koehring Company $35.24 *per gear.* How much can it save you?

Bethlehem Circular Forgings are available in carbon, alloy, or stainless steels, as well as certain heat-resistant grades. 10 to 48-in. OD. 100 to 2,000 lb. As-rolled, or rough-machined to specifications. Call or write the Bethlehem sales office nearest you for full details.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

NOTICE *the thin disc shape on this 395-lb gear blank. A cinch on the Slick Mill!*

BETHLEHEM STEEL

For more information, circle No. 392

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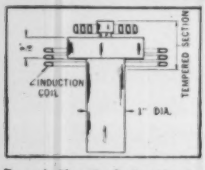
HIGH FREQUENCY INDUCTION HEATING UNITS

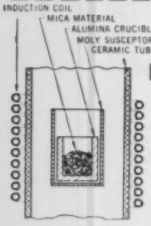
Lepel induction heating equipment represents the most advanced thought in the field of electronics... the most practical and efficient source of heat developed for numerous industrial applications. You are invited to send samples of work with specifications. Our engineers will process and return the completed job with full data and recommendations without cost or obligations.

TYPICAL INDUCTION HEATING APPLICATIONS



Punch Heads Selectively Tempered

Diagram shows arrangement for selectively tempering heads of alloy steel punches. The use of a combination type solenoid and pancake induction coil reduces hardness from Rc 55/56 to Rc 41/44, improving resistance to brittle fracture at the head of the punch. In this case a heating cycle of 55 seconds provides uniform tempering. A multiple position fixture, processing 4 pieces at one time, speeds up production.



Heating Non-Conducting Materials To High Temperatures

Laboratory analyses frequently require heating of non-conducting materials to temperatures of 3,000 to 3,500° F. in vacuum or special atmosphere. This can be accomplished by induction heating with the aid of a metal susceptor. Diagram shows the fusion of mica samples in an alumina crucible, using molybdenum susceptor. A ceramic tube surrounding the susceptor isolates the work for fusion in a vacuum. The molybdenum susceptor is heated by induction, which in turn, heats the crucible by radiation.

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Electronic Tube Generators from 1 Kw to 100 Kw.
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55th ST. & 37th AVE., WOODSIDE 77, N. Y.

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PRICES & SUPPLY

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	29	32	34
304L	34	37	40
316L	47	51	56
321	35	38	41
347	41	45	49
430	23	26	28
Inconel	60	70	81
Nickel	52	63	73
Monel	54	64	74

[a]Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.40-10.65
Electrolytic (0.25-0.75 lb)	9.10- 9.75
Black Plate	8.20

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.5
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.5
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.0
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.5
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.5
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.5
Vinyl	1.0	2.0	2.5
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a]Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice. [b]Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

A convenient new guide to properties and uses . . .

ASBESTOS:

Its Industrial Applications

by D. V. ROSATO

Assistant Plant Manager
Research Division, Plastics Plant
Raytheon Manufacturing Co.

1959, 224 pages, $5.75

The author compiles and presents all available data on the properties and applications of asbestos, including recent advances. The book identifies the broad usage of asbestos in many engineered products. It serves as a convenient guide to various branches of industry including research and development groups, manufacturers, engineering schools, market research groups, and sales management. In addition to acquainting industry with asbestos products in a great variety of fields, the book also reviews the types of asbestos material available, their properties, and methods of manufacturing to further the understanding of the variables which exist in handling asbestos.

CONTENTS: Industrial Applications of Asbestos; Properties of Asbestos; Asbestos-Cement; Tile; Asbestos Heat Insulation; Asbestos Electrical Insulation; Asbestos Friction Materials; Asbestos Textiles; Plastics; Asbestos Packings and Gaskets; Asbestos Filters; Other Products; Census on Asbestos Products; Bibliography; Index.

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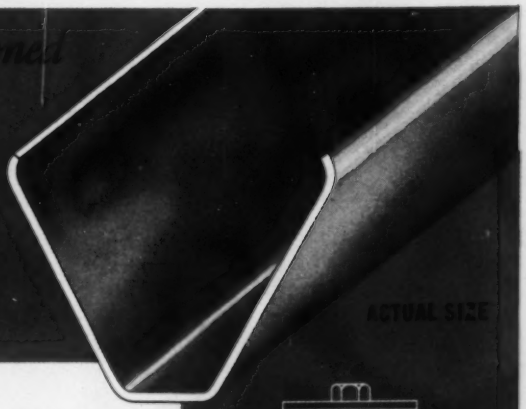
another idea roller die, cold formed

by **VAN HUFFEL**

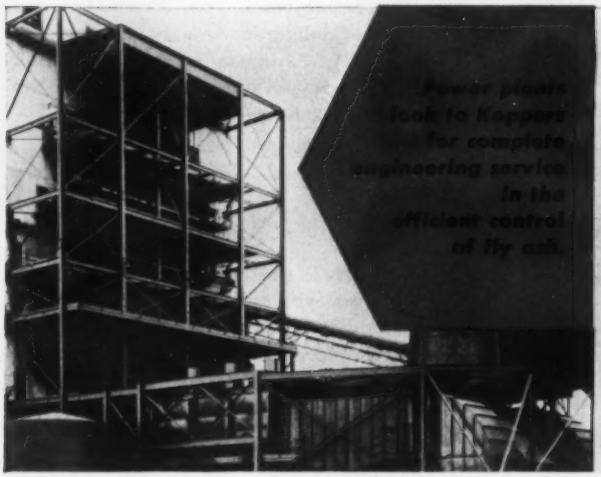
FOR KOPPERS ELECTROSTATIC PRECIPITATORS

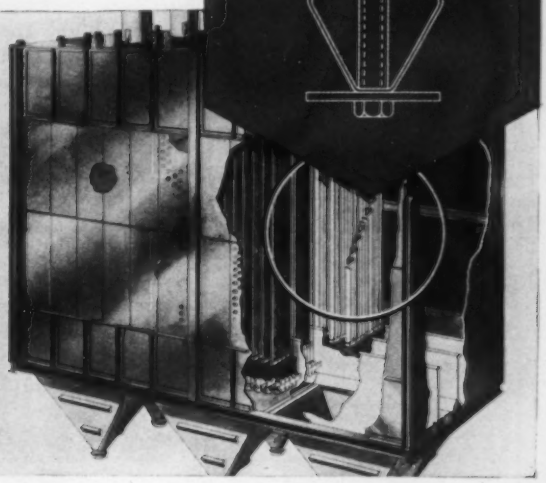


This V-Pocket Electrode section, produced for Koppers Electrostatic Precipitators, is another of the many ideas Van Huffel roller die, cold forms in various metals for a wide variety of applications.

Whether you require a simple or complex shape—in hot or cold rolled steel, stainless steel, high strength steel, coated steel, aluminum, copper, painted or plated metals—for parts in such widely diverse fields as material handling, building construction, communications, transportation, farm implements, furniture and appliances—it's probable Van Huffel's experience, facilities and products can help you cut costs and make a better product. The handbook shown below tells you how.

Where ideas *take shape*





MAIL COUPON FOR FREE METAL SHAPES HANDBOOK . . .

48 fact filled pages on material selection, fabrication methods, tolerances and dozens of illustrated ideas that have taken shape in metal.

Name ..... Title .....

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VAN HUFFEL TUBE CORPORATION • WARREN, OHIO

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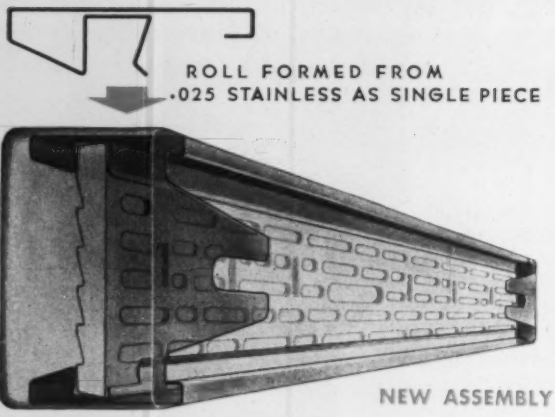
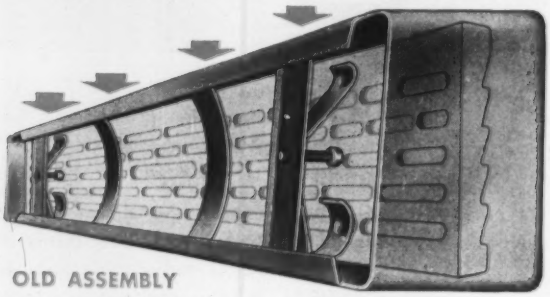
how one Roll Formed shape *eliminated six clips* and simplified an assembly





IN DESIGN

An expensive stamping and six clips went into this assembly. The stamping had a bad finish and cracked. Now it's Roll Formed from stainless. The finish is bright, shining and can't stain in use. Cracks are eliminated.

IN PRODUCTION

With the stamping the customer inserted a plastic strip and then welded the clips to retain the strip. Screws were positioned manually. Stampings were not uniform. Plastic breakage was high. The new Roll Formed section eliminates the welding operation, guarantees close tolerances, eliminates plastic breakage and cuts assembly time. Screws are not needed.

IN PURCHASING

Rejects were high. Components were hard to get and stampings came from separate suppliers. Deliveries were off-schedule. Now—Roll Formed sections come from one source and are delivered weekly to an open order. Stainless sections are interwoven with paper to protect finishes. Rejects have been eliminated.

CAN TECHNIQUES LIKE THESE HELP YOU?

Probably yes. The Roll Formed man can tell you. He'll go over your prints . . . work out an applicable section . . . plan deliveries with you. Meanwhile, you'll want Roll Formed Bulletin 1017A. It shows how Roll Formed techniques give greater design freedom, increase production and help eliminate purchasing headaches. Get Bulletin 1017A today.

METALS AND TECHNIQUES

Your sections can be produced in: carbon, galvanized and stainless steel; aluminum, copper, zinc and clad metals. Tubing, shapes, channels and angles can be punched, notched, pierced, cut to length and delivered free of burrs to match your production schedule.

MAIN OFFICE AND PLANT
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ROLL FORMED PRODUCTS
COMPANY

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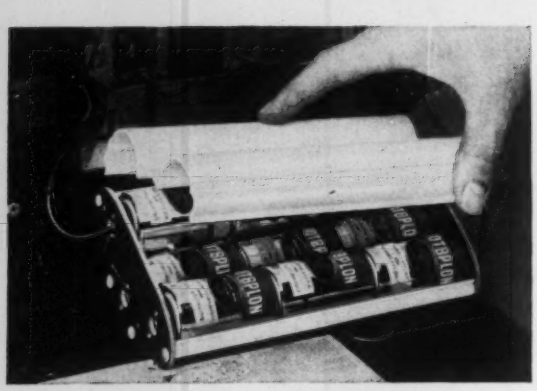
NICKELOID METALS IN A *Woman's World*

Part of that happy gleam in the eyes of a modern homemaker is because of the convenience, the ease, and the pleasant decorative warmth of her kitchen. Along with the soft woods and pleasant colors she revels in the easy-to-maintain gleam of clean bright appliances, housewares, working surfaces and decorative trim. The efficient chromium and the warm copper . . . seen so much about the modern kitchen . . . are most probably stamped or fabricated from one of the versatile galaxy of Nickeloid Metals. There's eye appeal and there's sales appeal in appliances and housewares which utilize Nickeloid Metals. Liked, too, by designers and production engineers. Complete information about Nickeloid Metals and the Nickeloid pre-finished metals method is contained in a special kit, which will be mailed you on request.

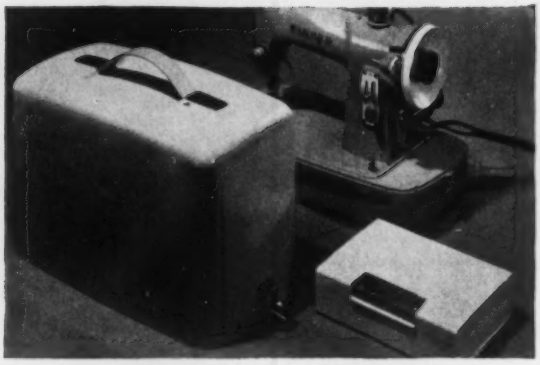
NICKELOID METALS
SINCE 1898

AMERICAN NICKELOID COMPANY, PERU 6, ILLINOIS Plants: Peru, Ill., and Walnutport, Pa.

For more information, turn to Reader Service card, circle No. 343



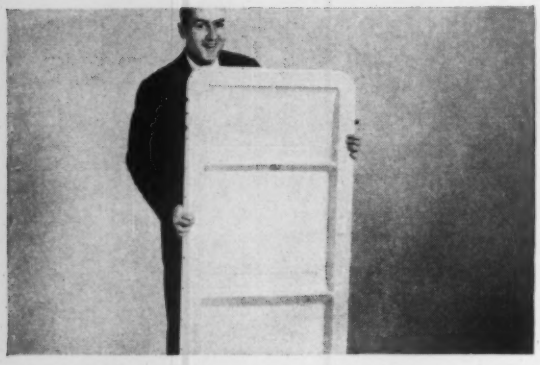
1 Extruded from styrene, this transistor radio's battery case:
(a) cushions vibration *(b) prevents short circuits*
(c) keeps batteries dry



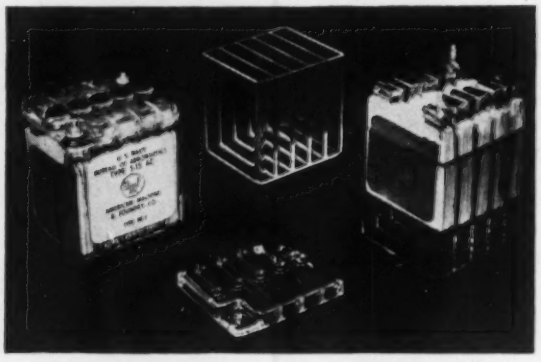
2 Molded of high-impact styrene, this case is notable for its:
(a) injection-molded depth *(b) strength to carry a 25-lb. load*
(c) colorful gleaming surface

Can you pass this test on Styrene Plastics?

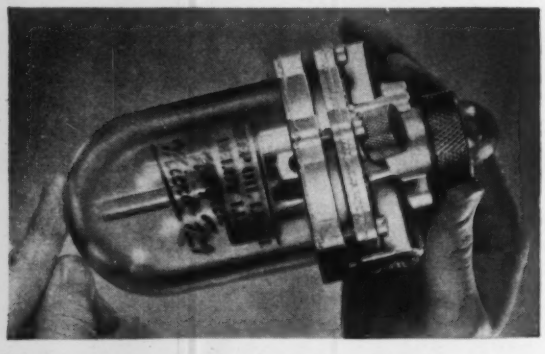
(You'll discover more of their potential as design materials)



3 Refrigerator door panels are fashioned of styrene for:
(a) impact strength *(b) insulation*
(c) lower material cost



4 It's a silver-zinc battery's case, molded of C-11 styrene for:
(a) transparency *(b) resistance to potassium hydroxide*
(c) production economy



5 This molded C-11 oil sight-bowl withstands pressures up to:
(a) 1200 psi *(b) 30 psi*
(c) 250 psi

ANSWERS... *to engineering and styling needs are found in BAKELITE styrene plastics.*

1. (b) Prevents short circuits. It keeps wiring from metal battery case.
2. Check (a), (b) and (c), but emphasize its deep, one-piece molding.
3. (a), (b) and (c) plus color variety.
4. (b) is most important, but (a) and (c) are advantages, too.
5. (a) Believe it or not—1200 psi!

If you have questions—about designing with plastics for function, serviceability, economy and appearance—please ask us. We'll be glad to answer on the practical design and engineering uses of vinyls, epoxies, phenolics, styrenes, and polyethylenes. Just write or call any of our offices or write Dept. CV-O4D, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto 7.

UNION CARBIDE

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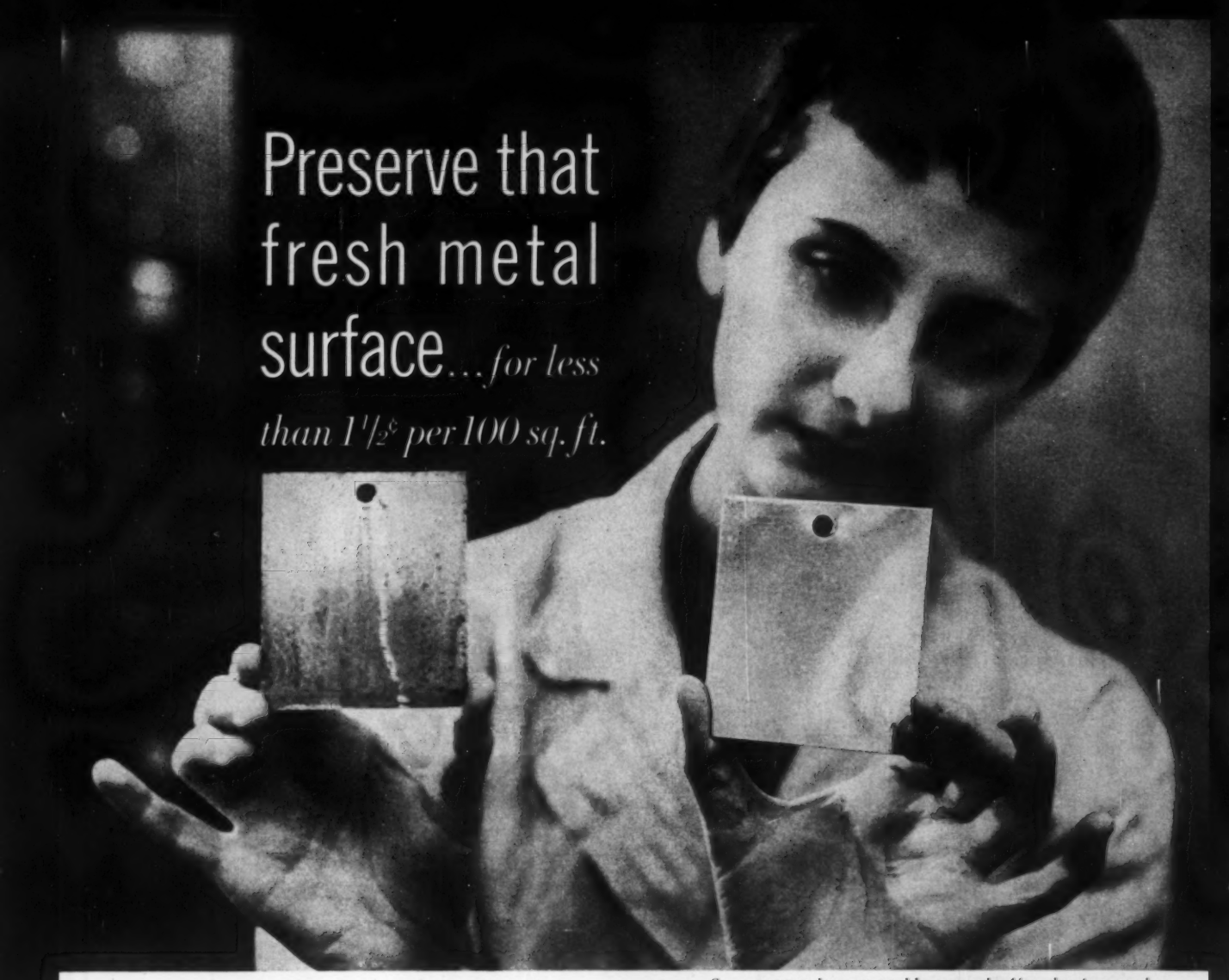
Preserve that fresh metal surface... *for less than 1½¢ per 100 sq. ft.*



Compare treated vs untreated brass panels. After cleaning, panel on right was rinsed in Entek 45 rinse; panel on left, in standard hot water rinse. Then panels were exposed to 100% humidity at 100° F. for 100 hours. Note how Entek 45 preserves "that fresh metal surface."

From Enthonics research come Enthone Enteks, a new series of rinse water additives which coat metal surfaces with an "invisible shield" against the atmosphere. Entek 45 assures faster drying, eliminates water spots and provides lasting corrosion protection to all metals. Entek CU-55 prevents tarnishing and spotting out of copper and brass even under tropical humidity conditions.

By adding Entek 45 to your final hot water rinse, you can prevent white salt corrosion of zinc and aluminum, prevent yellowing of nickel plate, prevent tarnishing of copper and brass, prevent black spots on cadmium plate.

By treating copper and brass goods or copper or brass plated items with Entek CU-55 you can prevent tarnishing, green salt formation, spotting-out and pit corrosion under high humidity storage conditions.

Entek protection lasts for months, yet costs less than 1½¢ per 100 sq. ft. to treat your parts, less than ½¢ per gallon to make up an Entek 45 solution!

Entek 45 produces an invisible, water-repellent organic film on the metal surface which sheds water rapidly and promotes stain-free drying. This same film acts as an invisible barrier between the metal and the moisture and oxygen in the air.

Entek CU-55 reacts with copper and copper alloys to form an invisible layer which has many times the corrosion resistance of bare copper and brass. Additionally, this layer has better solderability and improves adhesion of lacquers and enamels.

Write today for complete literature on both of these products to Enthone, Inc., 442 Elm Street, New Haven, Connecticut.

ASARCO

ANOTHER PRODUCT OF *Enthonics* RESEARCH

ENTHONE

A Subsidiary of American Smelting and Refining Company

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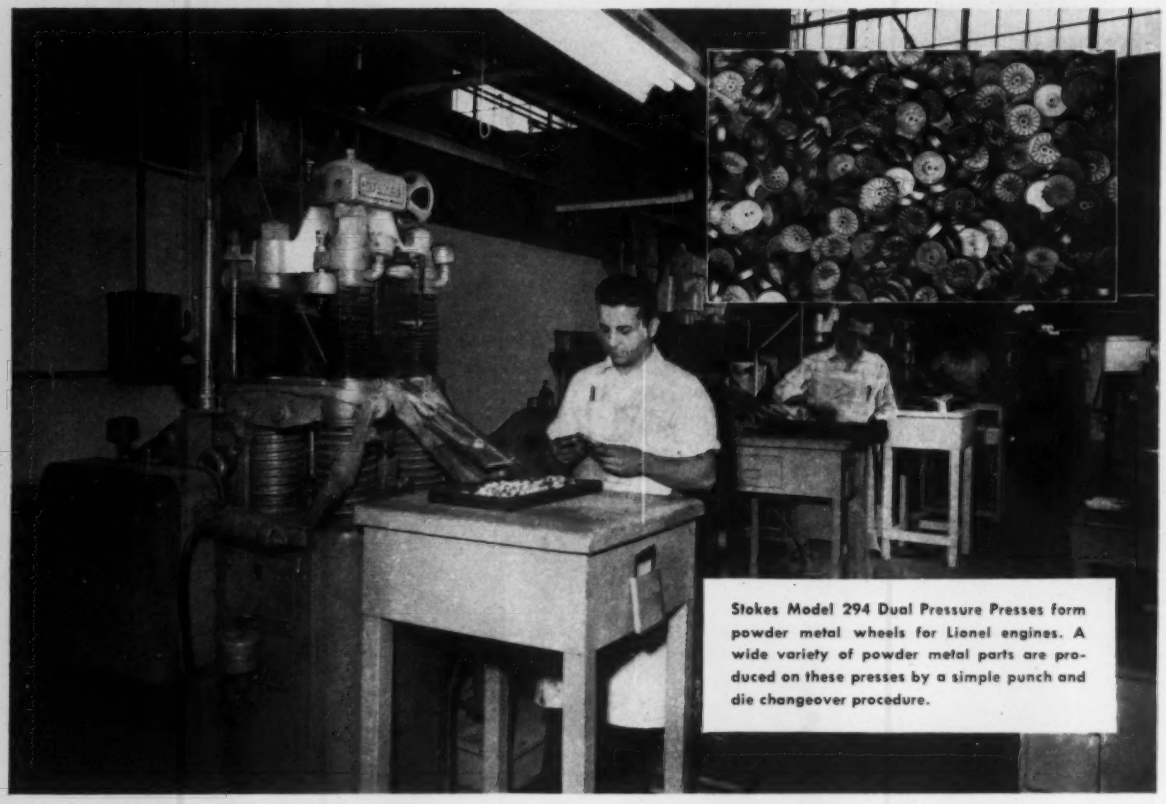
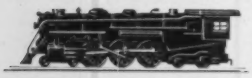


Stokes Model 294 Dual Pressure Presses form powder metal wheels for Lionel engines. A wide variety of powder metal parts are produced on these presses by a simple punch and die changeover procedure.

Stokes precision presses help Lionel model trains run on powder metal wheels



The name Lionel is synonymous with enjoyment to boys of every age. Since 1900, Lionel has manufactured hundreds of thousands of model train sets. In an effort to increase quality and reverse rising cost trends, Lionel purchased a battery of Stokes Powder Metal Presses several years ago to form many of the trains' parts. Today, over ½ million parts are produced each day on Stokes precision presses.

For example, Stokes presses form iron car wheels from powder metal. Unlike machine punched wheels, powder metal wheels are heavier. They lower the train's center of gravity and give it added stability. Finished wheels are more uniform and realistic. What's more, powder metallurgy has reduced wheel costs over 40%.

Perhaps powder metallurgy can cut your costs and save metal over conventional machining methods. It can aid you in getting properties of metals, alloys and mixtures unobtainable through other methods. And Stokes can help you determine production costs . . . handle complete laboratory production for sampling . . . include design and fabrication of punches and dies . . . and recommend types of equipment. Why not look into it further. Give Stokes a call . . . today.

Tabletting Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

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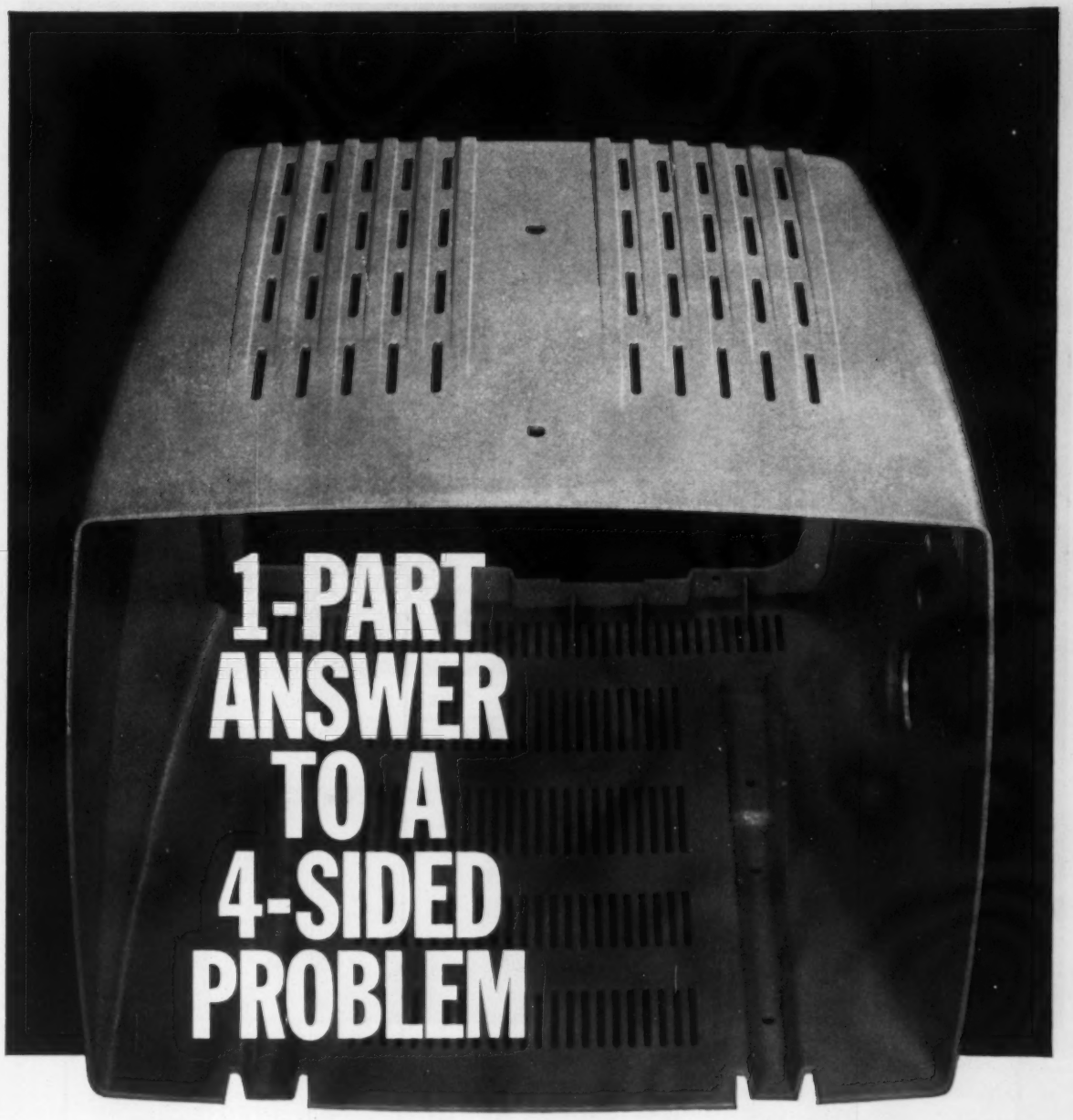

Just one shot on an injection press, and out comes this complicated 17-inch television cabinet weighing 1970 grams! Openings and grilles on all four sides required a mold opening in four directions. General American's ability to mold a cabinet like this means expanded opportunities in the use of plastics in all industries—since skilled die-makers working with production engineering experts assure the successful execution of the most demanding designs.

Have you thought that perhaps your part or product could be produced more efficiently and economically in plastics? With greater eye-appeal? Techniques developed by years of molding experience, together with the unequalled facilities at General American provide a source upon which you can call—and depend.

In plastics, as in so many other areas, *it pays to plan with General American.*

Plastics Division

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street · Chicago 3, Illinois

Offices in principal cities

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To insure you substantial savings of valuable time and to give you volume prices on even small orders, U.S. Rubber has now put into effect a standard warehousing and pre-packaging plan. For the first time, small and medium quantities of high-impact, thermoplastic U.S. Royalite—which include 36 combinations of the most popular gauges and colors—are stocked and pre-packaged at the factory, ready to be shipped in quantities as small as 3 sheets, 54" x 94". Result: within 48 hours from the moment your order arrives, your shipment of U. S. Royalite is set to go . . . at prices that save you up to 20%. Don't fail to take advantage of this time-and-money-saving opportunity...soon! For immediate service phone Chicago—Dickens 2-1800 — Sales Service Dept. or write below for information and samples.

US Royalite

the tough, lightweight, handsome sheet plastic fortified with rubber. Unaffected by oils, greases, most acids, alkalis. Forms to any shape in sharp detail, with no seams or rough edges. Already used for products like luggage, truck liners, housings, containers.

ROYALITE PLASTIC PRODUCTS

United States Rubber

2674 North Pulaski Road, Chicago 39, Illinois

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Troyfelt, a family of synthetic felts in non-woven form, offers Dacron and Orlon in an entirely new dimension!

TROYFELT is a non-woven synthetic felt manufactured by an exclusive process which *mechanically interlocks* the fibers rather than relying on a binder chemical or fiber. This results in a *uniformly* stronger material with fewer design limitations.

We can make it to your specification for thickness, density or permeability. We can make it to match SAE specifications for thickness, weight and density. We can make it out of straight Dacron, Orlon or a blend.

You can use it for stopping or collecting dust or dirt...for polishing...for damping sound and vibration...for self lubricating applications...for padding ...for gasketing and sealing...for insulating...for wicking. Anywhere a natural felt is not doing precisely the job you want...wherever you need greater strength and abrasion-, chemical- and heat-resistance — TROYFELT offers the complete solution. And, because it can be made in so many different forms, about the only limit to its use is your own imagination.

We'd be glad to send you our just-published bulletin and samples of the material. It describes typical applications and gives detailed tables of properties.

TROYFELT ... *by the pioneers in non-woven synthetic felts*

INDUSTRIAL PRODUCTS DIVISION • TROY BLANKET MILLS

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CARBON AND ALLOY STEEL INVENTORIES...

They can and will—if you let *Frasse* stocks be your inventory! Your cost for steel ready for use will be less. You'll save the cost of labor, handling, processing and obsolescence...free plant space and idle capital for profitable use. You incur no expense until material is needed...then only the cost of steel—*not* the purchase price PLUS the *high cost of possession.*

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Weigh the advantages of this modern solution to steel inventory problems. You get broad selection, fast deliveries—and the help of specialists that offer a wealth of technical information and problem-solving techniques. Place future orders for the carbon and alloy bars you need with Frasse—*your* Steel Service Center. You'll find it convenient...and far more economical than maintaining your own inventory.

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B1113	Ledloy	4142
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3M COMPANY CHEMICALS THE RAW MATERIALS OF PROGRESS

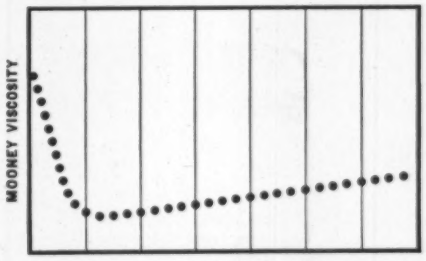
NEW FLUOREL® 2141

BRAND ELASTOMER

Its Mooney Scorch Rating is ideal for the fluorinated rubber processor because it makes possible fast, more economical cures with fewer defects, less scrap, fewer rejected parts. Material can be reprocessed with greater safety.

A SIGNIFICANT BREAKTHROUGH in elastomer processing has been made possible by 3M research through development of its new FLUOREL 2141 Elastomer.

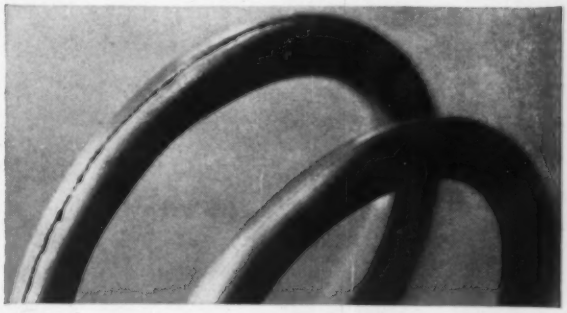
This remarkable new product has a Mooney Scorch Rating outstanding among fluorinated elastomers. The range permits the rubber processor to achieve fast, more economical cures with fewer defects, less scrap and fewer rejected parts. The inherent safety of FLUOREL Elastomer 2141 allows repeated reprocessing to produce high quality parts that meet military specifications or other critical end uses.



MOONEY SCORCH CURVE for FLUOREL 2141 Brand Elastomer.

At the same time, the outstanding physical qualities of the elastomer are retained. They include: non-combustibility, excellent resistance to corrosive chemicals, fuels, solvents and ozone, minimum compression set, rated for continuous service at 400° F., and the ability to tolerate 600° F. temperatures for reduced periods under certain service conditions.

If you use or work with elastomeric materials, it will pay you to examine the remarkable features of this new product. Examine, too, your present rubber products with an eye toward increasing their life and quality through use of FLUOREL 2141 Elastomer. For complete data, write today on your company letterhead to: 3M Chemical Division, Dept. KAR-30, St. Paul 6, Minnesota.



FLUOREL 2141 "O" ring, bottom. Note freedom from defects because of the improved scorch characteristics of FLUOREL Elastomer "O" ring as opposed to elastomer at top of photograph.

"FLUOREL" is a reg. T.M. of 3M Co.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

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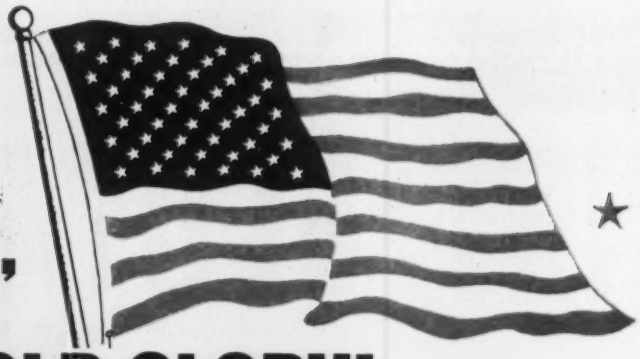
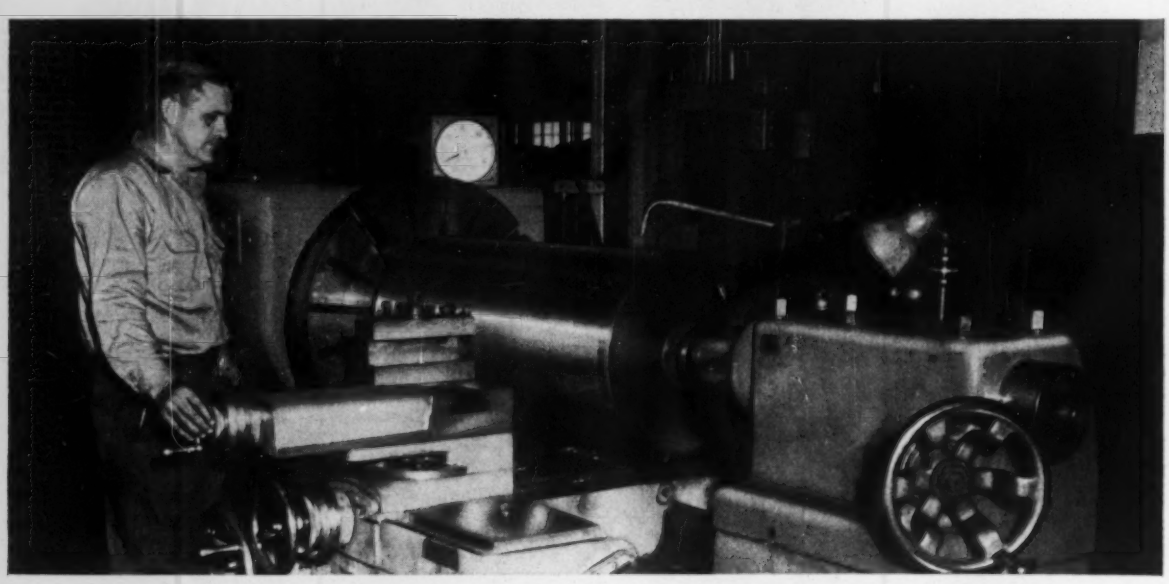


A NEW "ROLL" FOR OLD GLORY!



ACIPCO CENTRIFUGALLY SPUN ROLL USED IN PRINTING NEW 50-STAR FLAG

Here is an interesting application for ACIPCO centrifugally spun steel tubing. The above view shows an ACIPCO Type 1025 steel roll — 19" in diameter and 44" in length — being machined prior to copper plating. The roll was subsequently engraved with the 50-star pattern, and then utilized for printing multiple reproductions of our new flag on fabric.

Wherever tubular steel applications exist . . . ACIPCO spun steel tubes serve. Completely equipped to produce a wide variety of centrifugally spun and statically cast products, ACIPCO can serve your requirements more efficiently and economically because all its facilities are "under one roof."

For expert consultation on centrifugally spun tube applications in your field . . . call on ACIPCO.

VERSATILE ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

SIZE RANGE
Lengths up to 40 feet have been produced to meet modern machinery requirements. O.D.'s from 2.25" to 50"; wall thicknesses from .25" to 4".

ANALYSES
All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special non-standard analyses.

FURNISHED
As cast, rough machined, or finish machined, including honing. Complete welding and machine shop facilities for fabrication.

Write for free illustrated catalog.

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SPECIAL PRODUCTS
DIVISION OF AMERICAN CAST IRON PIPE CO.
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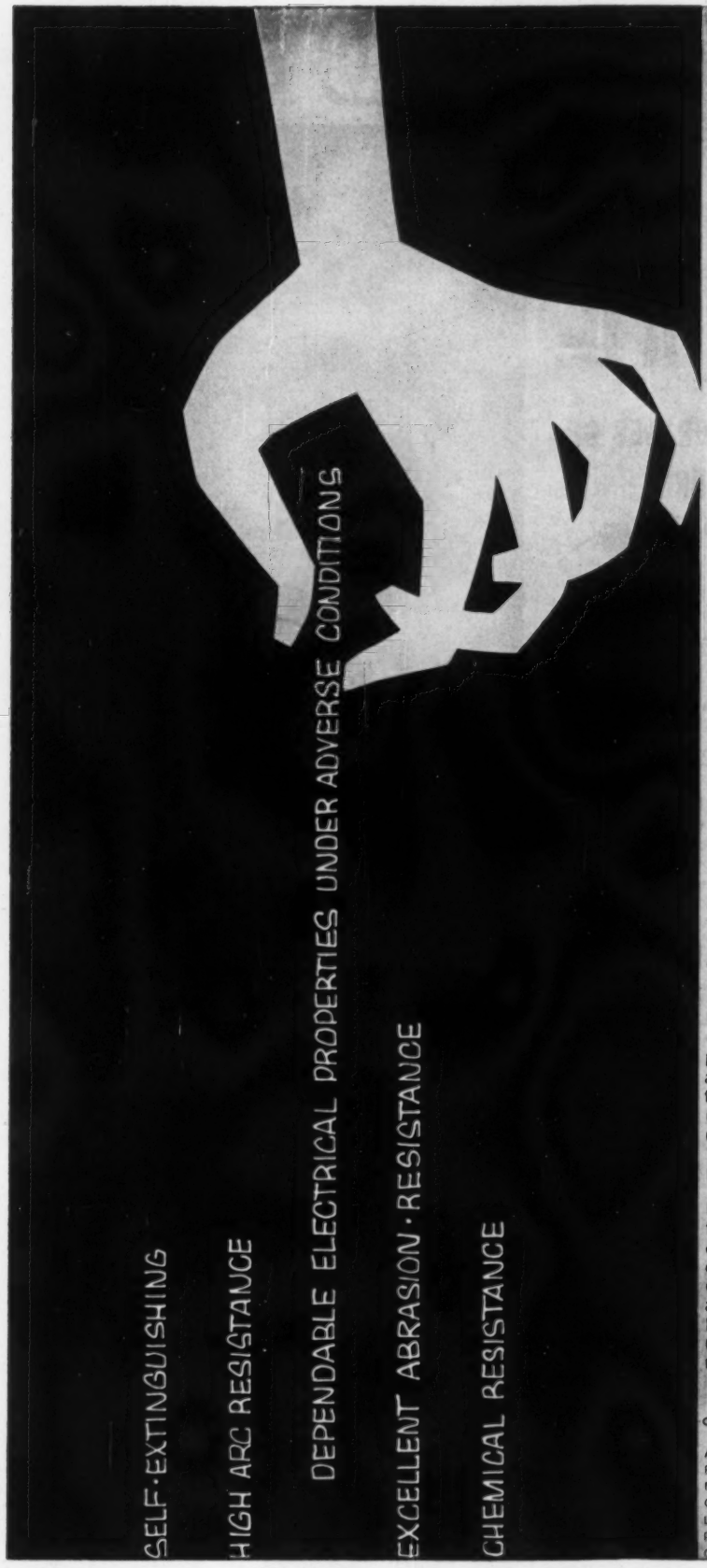

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CYMEL 3135–3136 (glass-filled) Additional distinctive properties: outstanding electrical properties; high impact resistance; extraordinary flame resistance; good dimensional stability. Typical applications: circuit breaker boxes; terminal strips; connectors; coil forms; stand-off insulators. Specifications: Cymel 3135 (MMI-30, MIL-M-14E, Federal L-M-181 Type 8; ASTM D704-55T Type 8); Cymel 3136 (MIL-M-19061, MMI-5).

CYMEL 592 (asbestos-filled) Additional distinctive properties: resistance to atmospheric extremes; high dielectric strength. Typical applications: connector plugs; terminal blocks; a/c, automotive and heavy duty industrial ignition parts. Specifications: MIL-M-14E MME; Federal L-M-181 Type 2; ASTM D704-55T Type 2, SP1 SPEC NO. 27025.

CYMEL 1077 (alpha cellulose-filled) Additional distinctive properties: Surface hardness, heat resistance, unlimited color range. Typical applications: appliance housings, shaver housings, business machine keys. Specifications: MIL-M-14E – Type CMG (in approved colors); Federal L-M-181 Type 1; ASTM D704-55T Type 1, SP1 SPEC NO. 30026.

CYMEL 1500 (wood flour-filled)–CYMEL 1502 (alpha cellulose-filled) Additional distinctive properties: Good insert retention. Typical applications: meter blocks, ignition parts, terminal strips. Specifications: Cymel 1500 (MIL-M-14E Type CMG, Federal L-M-181 Type 6, ASTM D704-55T Type 6); Cymel 1502 (MIL-M-14E Type CMG, Federal L-M-181 Type 7; ASTM D704-55T Type 7.

BEETLE® UREA (alpha-filled) Additional distinctive properties: Economy of fabrication, economy of material, myriad translucent and opaque colors. Typical applications: wiring devices, home circuit breakers, tube bases, appliance housings. Specifications: Federal L-P-406A, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM), SP1 SPEC NO. 27026.

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Twenty paper-base grades . . . fourteen fabric base grades . . . each with its own particular qualifications, stand ready to solve your problems. Use them for postforming, electrical insulation, gears, bearings, printed circuits . . . and hundreds of other uses. Sheet sizes range up to 48″ x 60″ in paper base, 36″ x 84″ in fabric base . . . and up to 3″ in thickness, depending upon grade desired. Special grades can be developed, if necessary, to meet your specifications. Farlite engineers are available for consultation with your staff.

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FARLEY & LOETSCHER MFG. CO.

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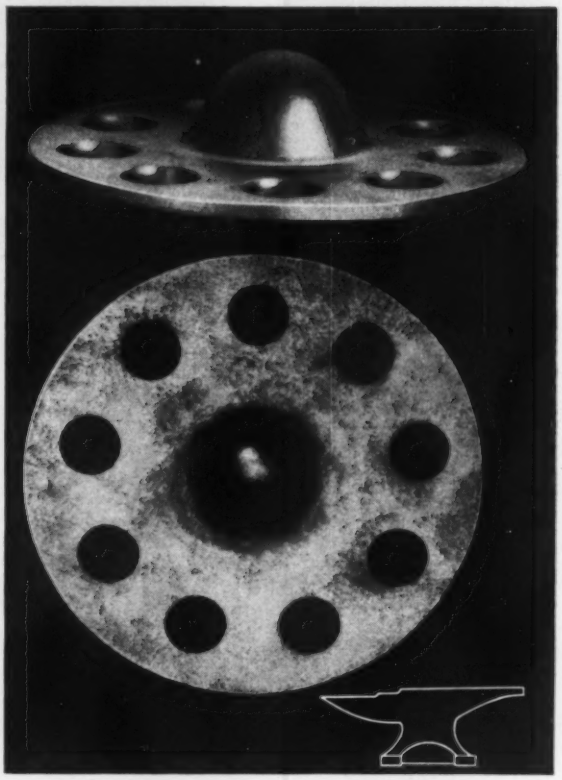
RITCO FORGINGS



...their strength alone merits your design consideration!

Forged-in toughness which assures dependable impact resistance at points of greatest shock and stress is, in itself, a sound recommendation for the use of Ritco Forgings. Their dense, fibrous structure and controlled grain flow provide maximum fatigue strength . . . still another important factor in their favor. Combine these with close-tolerance accuracy and flawless finishes which speed up parts assembly and it's easy to see why Ritco Forgings are being written into more and more product designs. *All* things considered, it will pay you to write them into yours, too. Send us your blueprints for estimates at no obligation.

Ritco also offers complete machining facilities and makes Special Fasteners and Upsets of ferrous and non-ferrous metals. What are your requirements?

RHODE ISLAND TOOL COMPANY

Member Drop Forging Association

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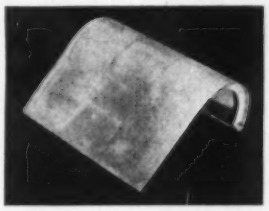
Report on Developments of

New Fansteel 82 Metal in Hypersonic Vehicle Prototypes

Design and development work on hypersonic flight vehicles by Boeing Airplane Company and other missile and airframe manufacturers has indicated some important use-possibilities for Fansteel 82 Metal. This new columbium-tantalum-zirconium alloy was among the materials fabricated into prototype leading edges for materials capability evaluations at 2000°F and over. Results verified Fansteel's own tests proving the metal's high strength-to-weight properties at elevated temperatures.



Excellent Oxidation Resistance

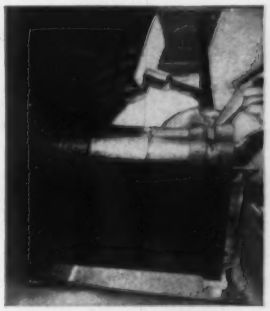
Exhaustive tests in the Fansteel laboratories prove Fansteel 82 Metal far superior in oxidation resistance to pure columbium. Calculated on the basis of weight gain during exposure at 2000°F in air, 82 Metal is ten times as resistant as the pure refractory metal. Sixteen-hour, 2000°F test in flowing air showed remarkable low scaling of 0.01 cm.

Tensile Properties of Sheet

The encouraging results of Boeing's prototype tests indicate 82 Metal's suitability for airframe and missile material. Average tensile properties are shown below.

Fansteel 82 Metal Easily Formed

In addition to its high temperature properties, 82 Metal has excellent fabricating characteristics. Ductile welds are made with little or no tendency to fracture in heat affected zones. It is easily fabricated at room temperatures, as worked or annealed. Its melting point is 4550°F and density 10.26 grams per cc (0.371 lb. per cu. in.).



Welding the Boeing prototype in an inert atmosphere chamber using tungsten inert gas process.

Design and Engineering Help

Fansteel engineers and metallurgists are now working with many other firms in adapting Fansteel 82 Metal to specific areas. They will be glad to cooperate with your own designers and production people in studying and applying this useful new metal. Just send us your print or part sample, or call in the Fansteel representative.

Available From Stock

For experimental purposes . . . Fansteel 82 Metal is available from stock in ingots, forgings, bar, rod, plate and sheet. Let us keep you informed of developments concerning this new alloy as they occur. Write for the latest technical bulletin.

TENSILE PROPERTIES OF SHEET

TEMPERATURE Degrees F	ATMOSPHERE	ULTIMATE TENSILE STRENGTH, psi.	YIELD STRENGTH .2% offset, psi.	ELONGATION % in 1 in.
70-80	Air	76,000	65,000	12
1800	Argon	59,000	53,000	1.5
2400	Argon	19,000	15,000	14

Photos Courtesy of Boeing Airplane Company

FANSTEEL METALLURGICAL CORPORATION
NORTH CHICAGO, ILLINOIS, U.S.A.

K602

For more information, turn to Reader Service card, circle No. 466

Wallex Casting on Tail Skid Protects Navy Jet Fighter

When navy jets land on pitching ships, jet tails sometimes hit and scrape the deck. To protect both the aircraft and the deck, McDonnell puts smooth pads on the tail skids of its Demon jet fighter. Cast of wear-resistant Wallex alloy, these pads rebuff impact and corrosion, create little friction to mar flight decks.

Curved Wallex casting brazed to steel plate forms tail skid pad assembly.

As our example above shows, the proper functioning of a whole assembly can often be insured by protecting just one small area from damaging wear. Castings of various Colmonoy alloys are doing just that, in hundreds of places. Colmonoy nickel, cobalt, and iron-base alloys are also applied as welding rod, electrodes, paste, and as Sprayweld Powder. Learn more about this remarkable group of alloys.

Ask for Colmonoy Hard-Facing Manual No. 79.

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*temperature indicating crayons**

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Tempilstik°—a simple and accurate means of determining preheating and stress relieving temperatures in welding operations. Widely used in all heat treating—as well as in hundreds of other heat-dependent processes in industry. Available in 80 different temperature ratings from 113°F to 2500°F . . . $2.00 each.

Send for free sample Tempil° Pellets. State temperature desired . . . Sorry, no sample Tempilstiks°.

Most industrial and welding supply houses carry Tempilstiks° . . . If yours does not, write for information to:

INDUSTRIAL DIVISION

Tempil° CORPORATION
132 West 22nd St., New York 11, N. Y.

Visit us at Booth 407, Great Western Exhibit Center, Los Angeles, Cal., April 26-28

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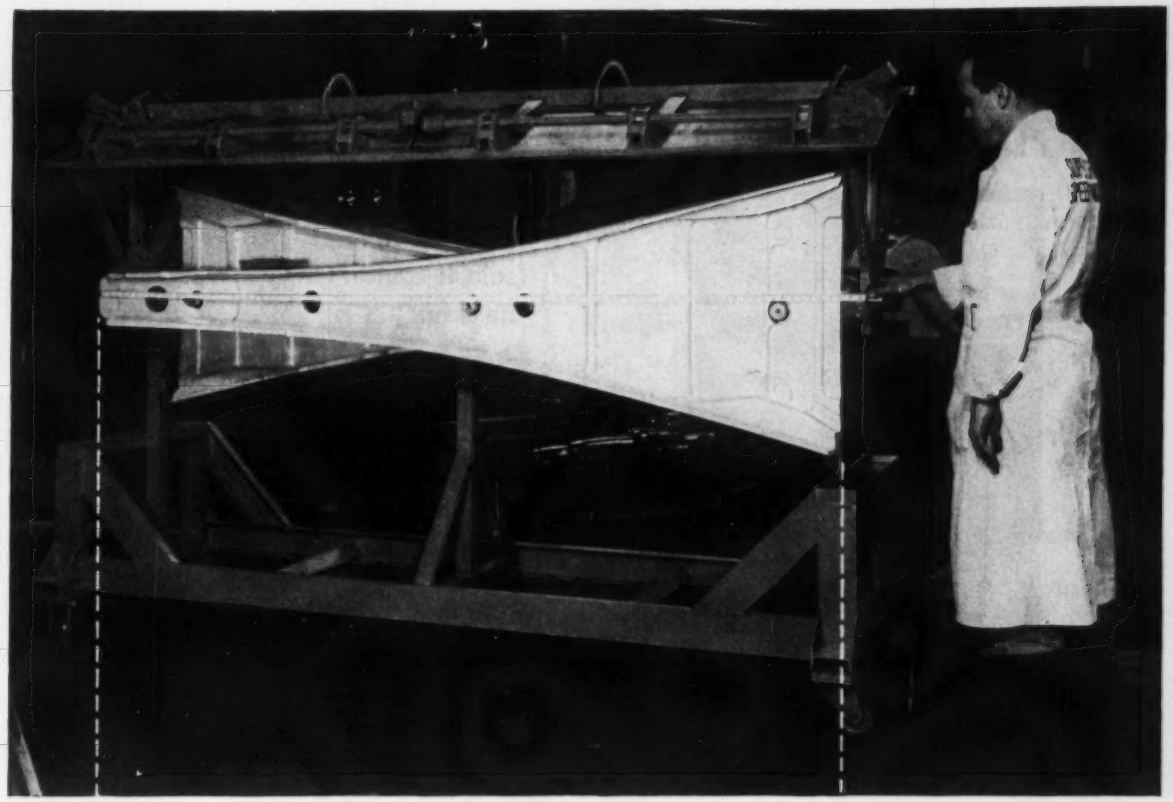


Can parts this long be barrel finished?

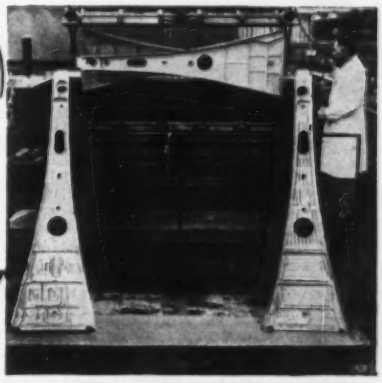
ALMCO Supersheen System

YES! With ALMCO's efficient, versatile barrel finishing equipment, the 93 inch wing spar above was finished in a two hour time cycle. Thirty inches long at the wide end and 8 inches thick, the spars are finished two at a time in a special ALMCO unit at McDonnell Aircraft Corp., St. Louis, Missouri. Previous hand methods required many additional hours of finishing time and it was difficult to maintain uniformity of the parts.

These aircraft wing spars are barrel finished to blend in radii and improve micro-inch finish on other surfaces through use of ALMCO Supersheen media and burnishing compounds. All surfaces receive the same treatment—rejects due to imperfect finishing are eliminated. Tremendous labor savings are made by using ALMCO's modern barrel finishing methods.

ALMCO's modern machines and methods—the Supersheen System—may help you achieve vital costs savings too. At ALMCO you receive trained counsel for your finishing problems . . . *free* sample processing in ALMCO's modern labs . . . skilled guidance in selecting the proper standard or custom-designed ALMCO machines and methods. Write today on your letterhead asking for an ALMCO sales engineer to call. Or send parts direct to ALMCO's lab with specs required.

Note "machining ridges" on foreground spars, prior to Almco Barrel Finishing. Supersheen Aluminum Oxide chips with Almco #10 compound are used in 2 hour finishing cycle.



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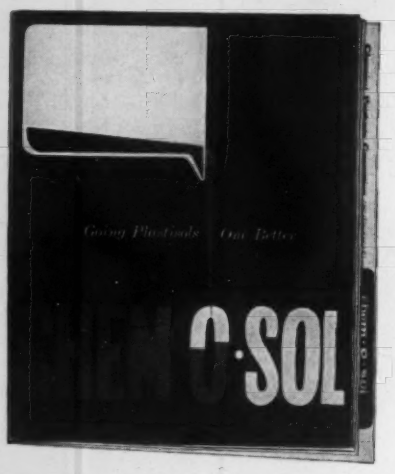

FACTS YOU NEED TO KNOW

about plastisols

This brochure brings you up-to-date on plastisols. A new edition of the definitive work in the field of polyvinyl dispersions, "*Going Plastisols One Better*—**chem-o-sol**", answers such questions as these:

- **What are plastisols?**
- **How are plastisols applied?**
- **How can we use plastisols?**
- **How have plastisols cut assembly costs?**
- **What important properties of plastisols make them useful to industry?**
- **What future uses for plastisols can be anticipated now?**

The booklet shows many ways of improving a product with **chem-o-sol** . . . how to simplify production . . . why Chemical Products Corporation, with its pioneering experience in plastisols, its vast facilities for research and production, is your best source of supply.

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Going Plastisols One Better

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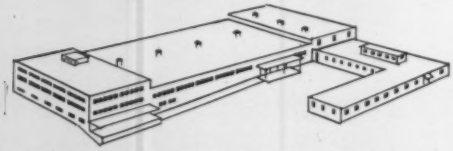

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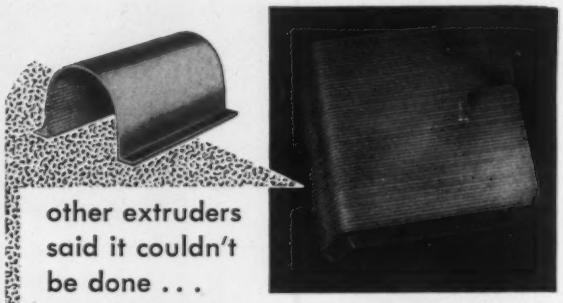

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Sub-Zero	SZH653	6.5	–85° F.	–75° F.	60"	28"	42¼"	47"	15"	16"
Sub-Zero	SZHC657	6.5	–140° F.	–125° F.	60"	28"	42¼"	47"	15"	16"
Rivet Cooler	RSZ503	5.0	–30° F.	–20° F.	42"	28"	41"	30"	16"	18"

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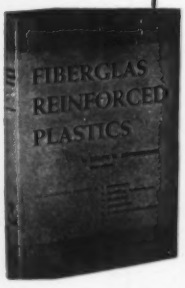

1954, 250 pages, $4.50

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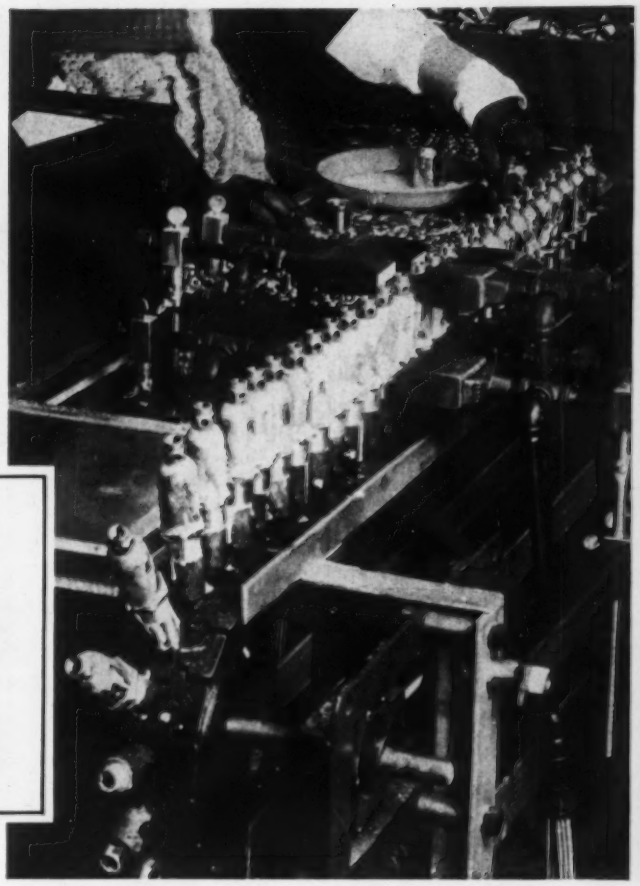

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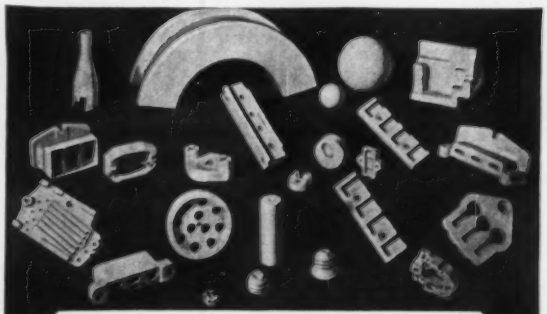

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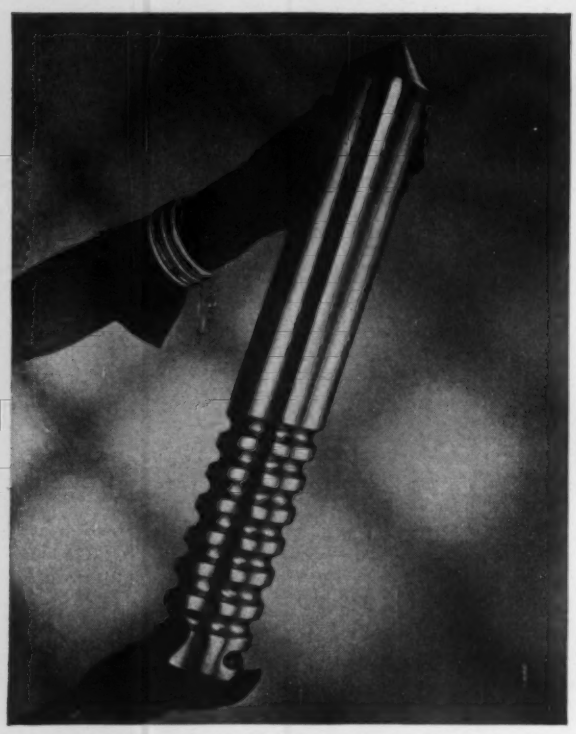

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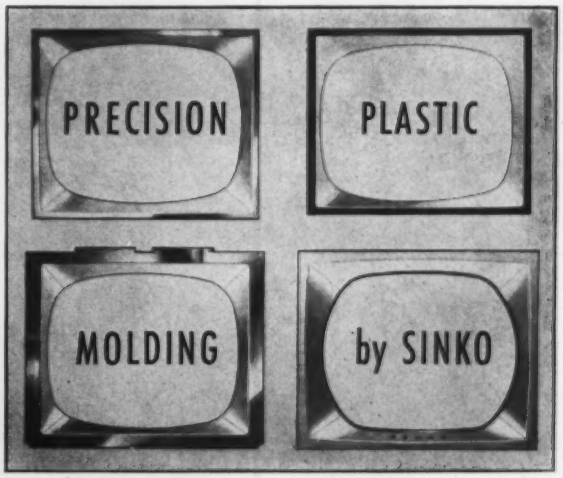

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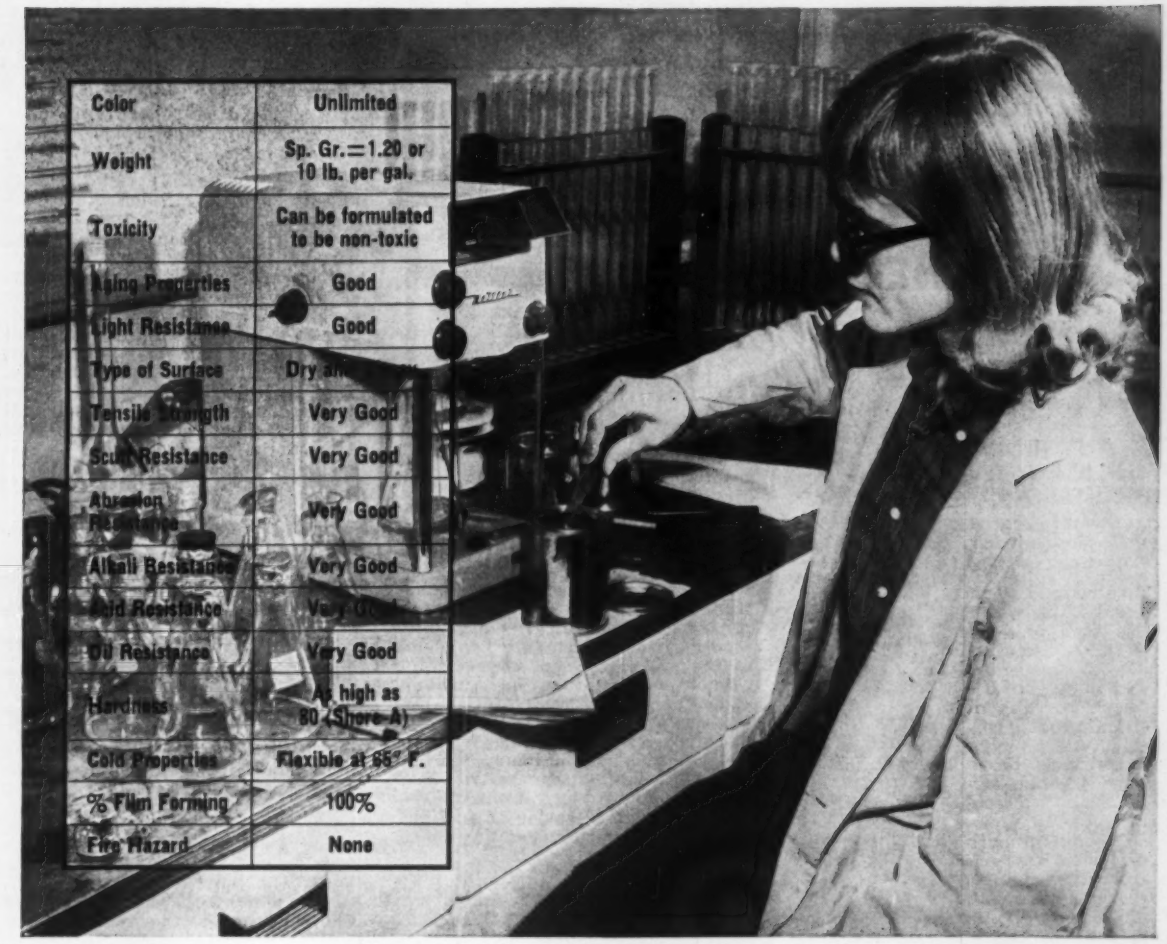

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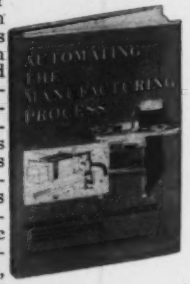
by GEORGE F. HAWLEY, *Vice President of Development and Engineering, Automation Engineering Laboratories, Inc.*

1959, 176 pages, $4.95



THE EMINENTLY sound ideas which this book presents merit the attention of all concerned with the use and development of special automatic machinery. It presents in practical terms some of the mechanical problems involved in developing automatic equipment for specific operations, such as assembly of components, packaging of individual products, bottle capping, feeding, etc. Management and production personnel will gain a greater appreciation for the problems encountered in developing successful machines, while designers and development engineers will find a machine development procedure which, if followed, should minimize their failures.

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2 VACUUM PROCESSING IN METALWORKING

by J. WESLEY CABLE, *Consulting Engineer*

1960, 256 pages, $5.50

THE RELATIVELY new field of vacuum technology receives complete, practical treatment here. The book encompasses the complete range of operations in the metalworking field. The first few chapters cover the general phases of vacuum technology, such as the means of producing low pressures and their measurement. Following these, the author devotes each subsequent chapter to a particular phase of vacuum processing. He also includes the latest developments, among them electron beam heating. In general, the aim of the book is to present vacuum technology in a descriptive manner, rather than in a highly technical form.

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3 NUCLEAR FUEL ELEMENTS

edited by HENRY H. HAUSNER, *Adjunct Professor, Brooklyn Polytechnic Institute and* JAMES F. SCHUMAR, *Associate Director, Metallurgy Division, Argonne National Laboratory*

1959, 432 pages, $12.50

CONTAINS the papers presented at the First International Symposium on Nuclear Fuel Elements held at Columbia University in January 1959. This book is the first to deal exclusively with the nuclear fuel elements. The twenty chapters include first-hand information from scientists in the U.S. and European countries who have worked on the development, design and fabrication of fuel elements. These scientists describe their own experiences. Among the individual topics presented by each chapter are discussions of the use of the fuel elements for reactors of the future, the standardization of certain types of elements, cost analysis for low-cost fabrication and reprocessing, metallic fuel elements made from uranium, thorium and plutonium, dispersion-type fuel elements, high-temperature fuel elements, and the behavior of fuel elements under reactor operating conditions.

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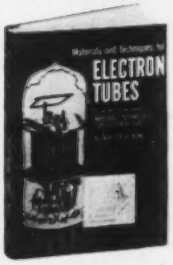
4 MATERIALS AND TECHNIQUES FOR ELECTRON TUBES

by WALTER H. KOHL, *Senior Engineering Staff, Sylvania Electric Products, Inc., a Division of General Telephone & Electronics Corporation, General Telephone & Electronics Corporation Technical Series*

1960, 640 pages, $16.50



HERE IS the completely revised edition of the previous "Materials-Technology for Electron Tubes," long known as the standard work on the subject in English. The text has been rewritten and reorganized on the basis of replies to a questionnaire submitted to a large number of competent users of the first edition. As a result, the text has been brought thoroughly up-to-date. The book covers all the material components of electron tubes and the methods of uniting them, such as joining of metals by brazing, glass-to-metal sealing, and ceramic-to-metal sealing. Chapters dealing with specific materials contain extensive tabulations of physical characteristics, chemical reactions with various reagents, and processes used in application.

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by MILTON B. HORN, *Group Leader, Acrylic R & D, Catalin Corp. of America*

1960, 192 pages, $4.50

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6 POLYESTER RESINS

by JOHN R. LAWRENCE, *Project Coordinator—Glidpol Resin, The Glidden Company*

1960, 256 pages, $5.75

HERE IS a comprehensive presentation of the unsaturated polyester resin industry. It covers all aspects from historic background, chemistry, curing mechanisms and manufacturing to techniques used in processing the resins for use in reinforced plastics, casting and coating applications. Particular emphasis is given to formulating resins for special properties such as weathering and flame resistance. The chapter on coating applications is the most complete coverage ever published on this relatively new use for polyester resins.

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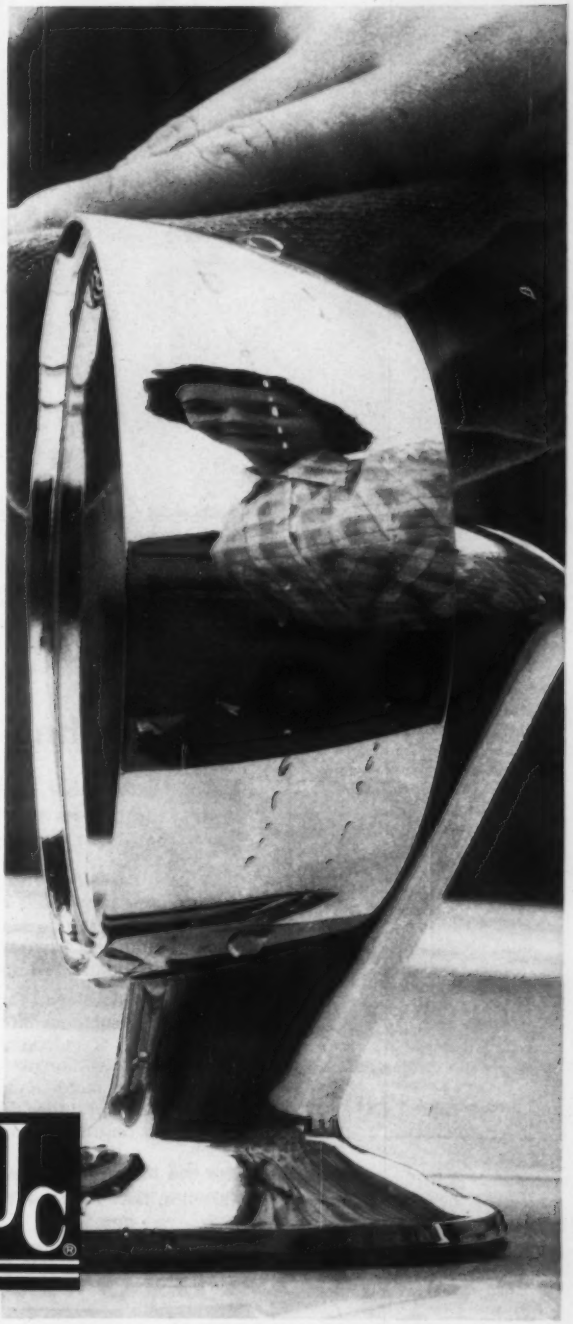

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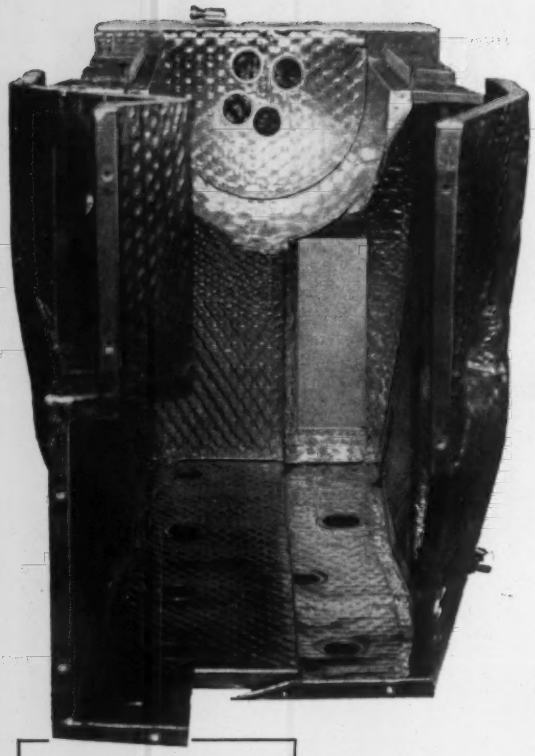

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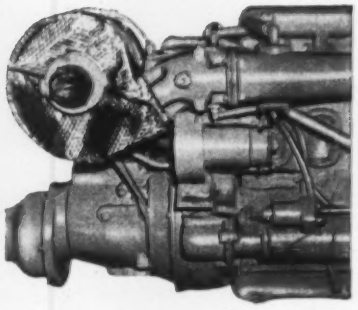

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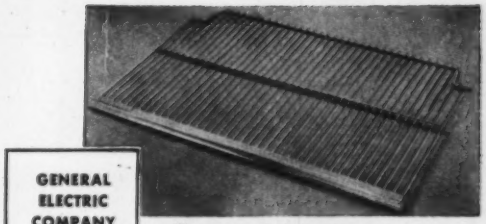

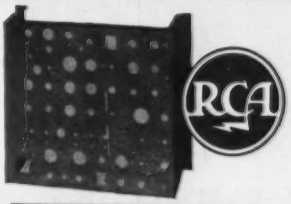

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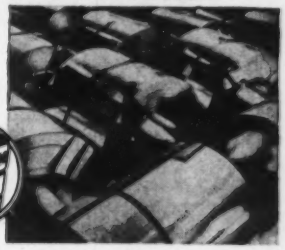

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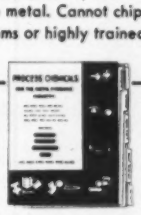

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Systems Approach to Materials Pays Off

THE LAST WORD

by H. R. Clauser
Editor

Late in January the Air Force and Westinghouse officially made public what had been hinted at cautiously during the past several months: that they had proved the feasibility of creating and producing single materials which, through solid state phenomena, can perform a number of electronic functions. (For details, see p 12 in this issue and p 133, Oct '59.)

Molecular electronics: a giant step

This development represents a giant step among the many advances that have been taking place in the electronics field as a direct result of applying the knowledge of solid state phenomena developed over the past two decades or so. The first major advance was the development of transistors, which were conceived essentially as materials that function as a single component. Now we have arrived at a new threshold of molecular electronics where, according to Westinghouse's Dr. S. W. Herwald, we can create solid state subsystems that achieve, entirely within themselves, electronic results such as have been gained previously only by assembling many varied components.

The systems concept

The basic guiding philosophy that fostered molecular electronics is the systems concept. And it is this aspect of the development that has important and far-reaching significance to all of us concerned with materials development and application. For here is perhaps the first large-scale demonstration that systems engineering can be applied to the internal structuring and functioning of materials. And it is reasonable and logical to expect that this same systems approach can and will be applied to develop materials that are subject to other inputs such as heat, nuclear radiation, and mechanical stress and displacement.

Of course, in a non-rigorous way, the systems approach has been applied to materials on the gross or macroscopic level for some years now. Composite materials such as sandwich and honeycomb construction, and reinforced plastics, are the best known examples. Their successful service performance depends upon the properties of two or more constituents that make up the materials system. Thus, in a reinforced plastic the fibers furnish the system its strength, and the plastic resin supplies support for the fibers which alone would lack rigidity.

Crystals and atoms are subsystems

But the systems approach on the microscopic (or atomistic) level goes beyond these gross subsystems to a deeper, more fundamental level. In effect, the crystals, atoms or electrons become the subsystems. In place of bonding strengths between resin and fibers, we deal with the binding energies between atoms. And instead of dealing with surfaces of constituent materials, we study the boundaries or interfaces of atomic or molecular domains.

Thus, we view solid materials as integrated wholes, composed of diverse atomic structures performing subfunctions which, taken together, provide the desired service performance.

Learn concept to speed new materials

The systems concept is a relatively new engineering discipline. But, as molecular electronics has already demonstrated, it can be effectively applied to materials. So, engineers and designers who will use and benefit from these integrated materials should become familiar with and apply the systems approach. By doing so, they will help themselves. They will also speed progress in the field by being able to translate their service requirements into terms that will allow the materials developer the broadest range of possible solutions.

CELANESE MATERIALS REVIEW

- **FORTIFLEX linear polyolefins**
- **FORTICEL cellulose propionate**
- **ACETATE molding compounds**
- **ACETATE sheeting**
- **POLYESTER resins**

CELANESE TECHNICAL SERVICE

How to put more experts on your team without extra cost

Celanese has the technical experts who can help you get the most out of plastic materials at any stage from design to final product testing. Here's a rundown on the technical services Celanese can provide with respect to molding.

DESIGN CONSULTATION

In the final stages of a design, you can call on Technical Service to review the design from the standpoint of molding technology. At this point it is possible to forestall problems of moldability and strengthen critical points by simple means such as changing a radius—without affecting basic design.

ASSISTANCE WITH MOLD DESIGN

Celanese Technical Service is prepared to review mold designs and offer recommendations. This includes mold cooling, gate location, sizes of gates and runners, etc. It's surprising how much a slight variation from optimum in mold design can affect the quality of the molded piece. Form retention, surface quality, freedom from warping and sinks, demand a precise knowledge of the geometries involved as well as of the materials.

MATERIAL SELECTION

Literally dozens of basic formulations of the Celanese plastics exist, and new formulations are possible to meet the needs of molders. They vary in melt index, flow temperatures, molding properties, and end-use properties. Often, formulations are available for special needs, such as flame retardant or light stabilized properties. Here Celanese technical assistance is invaluable in coming up with formulation recommendations that will be most suitable for your product.

EQUIPMENT AND ITS ADAPTATION

Celanese Technical Service will be glad to discuss your equipment requirements or needed modifications. For example, you may benefit from their knowledge of auxiliary molding equipment, or cooling processes, or the details of molding machinery.

PILOT MOLDING SUPERVISION

Celanese technical experts will help you supervise the first run of material. If material difficulties arise at the molding trials, they will make suggestions for changes and cooperate with you on additional trials. If you desire, they will send samples of the molded parts to Celanese Service Laboratories for evaluation.

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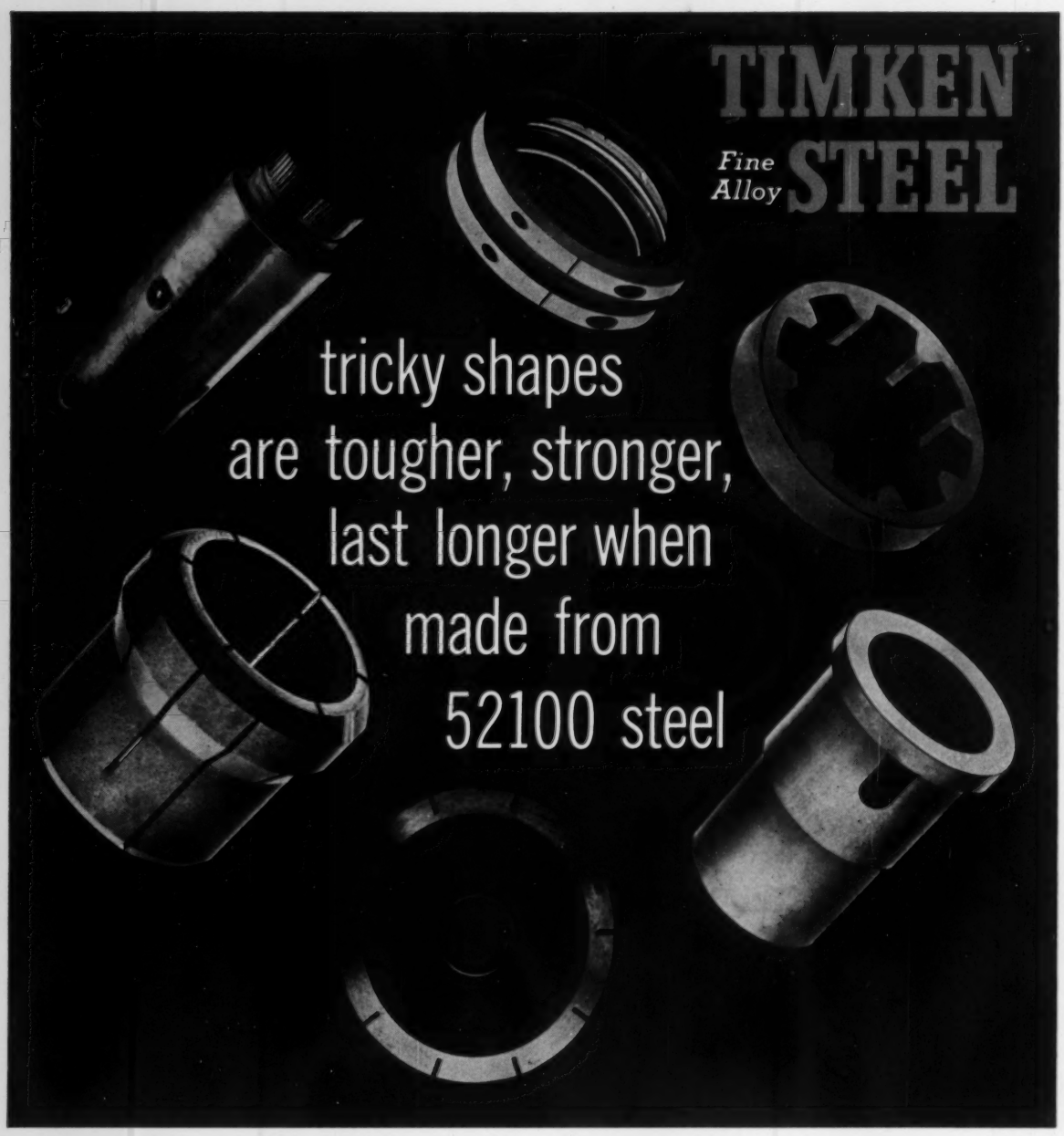

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